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ABSTRACT

This theme issue discusses education of gifted students in the areas of math and science. The issue contains several articles, an editorial, a program description, and a profile of an educator. "Our Most Important Investment for the Future: The Education of Our Youth" (Marian C. Diamond) describes educational programs of the Lawrence Hall of Science of the University of California at Berkeley. "Making Math and Science Accessible and Meaningful to Girls: An Economic Imperative" (Mary Thomas-Vallens) offers new paradigms for bias-free math and science education. "Accelerating in Mathematics: Academic and Social-Emotional Impact" (Terry A. Thomas) reports findings of a study of the benefits from Academic Talent Search fast-paced mathematics instruction. In "Barbara Graham's Animal Classroom," Barbara Graham discusses the role of animals such as mice, frogs, snakes, fish, and birds in sixth-grade math investigations, science themes, and literary works. "Fast-Paced High School Science for the Academically Talented: A Six-Year Perspective" (Sharon J. Lynch) discusses a summer residential program initiated by the Johns Hopkins University Center for the Advancement of Academically Talented Youth. Other articles include: "Mathematical Thinking at Its Best" (Marcy Cook) and "Math in Motion: A Hands-On Creative Approach to Teaching Mathematics in Elementary Schools Using Origami" (Barbara Pearl). (Most papers contains references.) (JDD)

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Communicator

Math & Science

ED 365 036

Our Most Important Investment for the Future: The Education of Our Youth

by Marian C. Diamond

In the past decade, about $100 million has been spent on new biology buildings at the University of California at Berkeley campus:

1. the Life Sciences addition, which consists primarily of laboratories for molecular and cell biologists;
2. a genetics and plant biology building, again mostly laboratories; and
3. the renovation of the old Life Sciences Building, which will house the library, classrooms, and research laboratories—a true university building.

The question I ask today is, "Who will fill these buildings in the years ahead?" As we look at the background of the majority of the children in our state today, it is apparent that science and math are not a major part of their past culture. Who, then, will utilize the rich resources in these University science buildings and others like them in the twenty-first century? To me it is essential to awaken the minds of the children today to the excitement and satisfaction of education in general and to math and science in particular.

After 30 years of studying the brain and its potential, I think it is time to apply what we have learned in the laboratory to the education of our youth. At birth we have all the nerve cells we are going to have in the outer layers of our brain, the cerebral cortex, the massive collection of nerve cells responsible for most of

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Making Math and Science Accessible and Meaningful to Girls: An Economic Imperative

by Mary Thomas-Vallens

Our country's competitiveness in the technological world is largely dependent on the success of girls and women in math and science. To some this may seem like a bold and perhaps farfetched notion. However, many recent studies not only support such a statement, but urge parents, educators and our society to pay heed to the claim. The education of girls today is critical to our future and to theirs.

In its highly acclaimed, comprehensive report, *How Schools Shortchange Girls*, the American Association of University Women (AAUW) negates the assumption that our public schools treat boys and girls equally. The study is a "synthesis of all available research on the subject of girls in school" (AAUW, 1992). Citing research from education, business, and government, the study shows that the future of girls and women is rapidly changing, and much is at stake. The girls of today will be needed to fill a great many technological jobs in the coming century. A strong course load in math and science is required, and yet girls are being turned off and turned away from pursuing these academic areas.

Consider the following: *Workforce 2000*, a report made for the United States Department of Labor, cites that by the year 2000, 66 percent of the new entrants to the work force and 47 percent of the entire work force will be women. The National Research Council reports that the

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PRESIDENT'S COLUMN

Sandra Kaplan

The need for an academically rigorous curriculum for gifted students is evident. The means by which to attain this academic rigor is not as evident. Regardless of the subject matter, there appear to be some strategies that have the potential to stimulate academic rigor:

- a classical orientation or perspective to what is known about the area of study or the foundation theories and principles in a body of knowledge
- a philosophical reference to the area of study, including an examination of the aesthetics and ethics that affect perception and appreciation of the subject matter
- a means of relating, connecting, and associating the subject matter under study with other areas of study
- a futuristic analysis of the subject under study or how and why it will survive, change, and/or develop in the future.

Academic rigor is not simply providing students with more or harder work. While these factors are used as traditional benchmarks for academically challenging curriculum by many, new definitions are needed to match these educational times.

31st Annual Conference
March 5-7, 1993
San Jose, CA
Don't Miss It!

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CAG encourages all interested parties to submit articles for publication. All submissions will be given careful consideration. Photos and camera-ready art work are particularly desirable. Student work should be accompanied by teacher's name and school. Send all material with your name, address, and phone number to Jean Drum, *Communicator* Editor, 7822 Belgrave Avenue, Garden Grove, CA 92641. You may phone Ms. Drum at 714/892-1745.

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CALENDAR

Saturday, January 23, 1993, 8:30 AM to Noon
CAG Board Outreach Program
Westgate Hotel, 1055 Second Avenue, San Diego
Call the CAG office for information, 818/888-8846

Saturday, January 23, 1993
Amphitheater Schools presents *Impact II*
Exploring Problem Solving with Treffinger and Maker
Tucson, Arizona
For information call P. MacDonald at 602/690-8079

Saturday, January 30, 1993...8:00 AM to 12:45 PM
Orange County Council 20th Regional Conference
Keys to GATE, Solving the Puzzle
Century High School
1401 South Grand Ave., Santa Ana, California
For information call Pat Phelan at 714/558-5643

Saturday, January 30, 1993...9:00 to 11:30 AM
Author and Book Workshop, Pacific Region
Ventura College
For information call M. Gosfield at 805/648-5391

February 3-6, 1993
California Association for Bilingual Education (CABE)
18th Annual Conference: *The Best of Both Worlds*
Anaheim Hilton and Towers, Anaheim, CA
For information call 714/369-6455

February 12-13, 1993
Colorado River Conference II
AEGT: Arizona Educators for Gifted and Talented
Lake Havasu City, Arizona
For information call P. MacDonald at 602/690-8079

March 5-7, 1993
31st Annual CAG Conference,
Theory into Practice: Orchestrating Excellence
Convention Center, San Jose, CA
For information call 818/888-8846

April 23-24, 1993
Association for the Education of Gifted Underachieving Students (AEGUS)
6th Annual National Conference
High Potential At Risk: Taking a Positive Approach
Portland State University, Portland, Oregon
For information call 206/230-5372

August 8-12, 1993
10th World Congress on Gifted and Talented Education
A Gifted Globe
Royal York Hotel, in the heart of Toronto, Canada
For information call 416/978-2400

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Articles and student work to be considered for future issues of the *Communicator* should be submitted to the editor, Jean Drum at 7822 Belgrave Avenue, Garden Grove, CA 92641. Student art work and photographs of students involved in school activities are especially welcome. Charts and graphs should be camera ready. Material should be submitted on Mac disks, if possible. Contact the editor for a style sheet regarding preferred format for articles, especially for bibliographies.

EDITOR'S COLUMN

The Two Cultures: Still Separated by a Wall of Incomprehension?

by Jean Drum

Jean Drum

"Math? Oh, I'm lucky if I can balance my checkbook!"
"You mean that little gizmo in the whatsis is what makes it work?"
"That's art? Looks like a two-year-old painted it!"
"The book? Well, no, I didn't read the book, but I saw the movie."

If C.P. Snow, the Cambridge don who gave the world the phrase "the two cultures" were to read those sentences, he would be quite likely to recognize them as evidence of his thesis, namely, that the intellectual life of western society has been split into two groups that neither understand each other nor particularly want to understand each other. These two groups are the scientists on one side and the liberal arts people (Snow calls them "literary") on the other. Snow, who was by training a scientist and by vocation a writer, was part of both groups and said that he felt he was moving among two groups who were much the same in intelligence, had about the same background and education, and earned about the same income, yet had almost "ceased to communicate at all."

Scientists, he said, live in a culture which is "intensive, rigorous, and constantly in action." They discuss, argue, and explore, but the arts (music is the exception) are for the most part irrelevant, and the books, the novels, the plays, the history, which are bread and butter to literary persons, have no importance for them. "Well, I've *tried* a bit of Dickens," is their experience with the liberal arts.

The literary culture, on the other hand, is equally impoverished (indeed more so, in Snow's view.) He found his literary colleagues in complete ignorance of the meaning of mass or acceleration which he says is the scientific equivalent of asking, *Can you read?*

It has been more than thirty years since Snow explored this problem, and the world had changed enormously. Technology has grown exponentially, and the vocabulary of science and the concrete results of applied science surround us on all sides. Our fingers fly across the keyboards of computers with the glorious possibilities for instant correction of typos, we and our luggage fly to any part of the globe in hours, and here in California we can see, via satellite, the Queen of England speaking at Windsor Castle or a Bosnian refugee child waving a tearful farewell even as those events are happening. English teachers use the vocabulary of science with casual familiarity and students at Caltech are required to take one non-science course every quarter. This seems like progress, but has the gap that Snow worried about really closed? Are the two cultures any closer to mutual comprehension and appreciation? Probably not.

At this point you may protest that it is not possible, not even reasonable, to expect everyone to be knowledgeable and competent in the details of science and technology. We don't all need to be able to solve a problem in physics. We don't all need to be able to explain recombinant DNA. We don't all need to be able to sight-read music either, or be able to discuss Wilson's Fourteen Points and their effect on the political dynamics of post-World War I Europe, or analyze the metaphysics of a sonnet by John Donne. A degree of specialization is sensible and efficient in any society, and having "two cultures" is probably inevitable and reasonable. After all, some members of a Stone Age tribe hunted mastodons while others perhaps made spears.

It's not the differences in details that are important, not whether you would rather read Dickens or work out a new program for your Mac, just as it's not the differences in details between two societal cultures (do you prefer potatoes, tortillas, or rice?) that really matter or cause friction. Problems occur when cultures cannot communicate to each other their most fundamental thoughts, and feelings and attitudes, and their basic approach to the questions of the human condition and experience. What a re-reading of Snow thirty years later suggests is that the great need is for the two cultures to come to understand how each thinks and works and views the world. Each side needs to be able to appreciate and respect the other side's mind set, walk a few miles in their moccasins, if you will.

An interesting research project which may shed some light on this issue was recently done by Sheila Tobias for the Research Corporation in Tucson, Arizona to explore the reasons why some gifted students fail to pursue science at the college level. The study was prompted by concern in our country about the projected shortfall of science workers and the fact that our science community is echoing Snow in decrying a general scientific illiteracy. In this project, six graduate students and one professor, all from nonscience fields, were recruited to "seriously audit" introductory physics or chemistry. Their task was to explore their personal encounters with the courses and "classroom culture" of beginning college science classes. These students had all been successful in high school mathematics and science classes and had chosen not to do science as undergraduates, not because they "couldn't" but because they felt they had a better option. As they audited beginning physics and chemistry classes, they did not find the rigors of science too hard. Indeed, the general feeling seemed to be that there was not *enough* mental challenge. They were put off by the emphasis on getting the right answer to a problem and going right on the next one, leaving no time for speculation on *why* it works that way. They wanted time to talk about side issues and discuss concepts, and they were bothered that the "real" science majors were so concerned with making fewer mistakes that they had no time to "enjoy the success, no time to use those skills in order to discover more or dig deeper." One participant said the science majors "ignored all the fun parts" of physics in their concentration on solving the equations.

Sheila Tobias' findings seem to suggest that the "literary" people are by no means unable to learn science, nor are they really unwilling or uninterested, but they do want to approach it from a different standpoint than that of the students who have been committed to science and only science from the beginning. Perhaps one way to bring the two cultures closer together would be to restructure the presentation of science classes for non-science majors—teach science their way (lots of chances to ask *why*) but at the same time make certain that they see how a scientist deals with problem solving. Everyone needs to see how the other half thinks, why they work the way they do and how they get their results, even when they don't choose to work that way themselves. As we all know, however, the best learning happens when teaching style and learning style harmonize. Research being done with socially diverse cultures is saying some of these same things. And remember, none of this implies "dumbing down" any subject in any way. It means teaching it differently. It is entirely possible that those who make a serious career of science will continue to be the "traditional" science types, but, if a slightly different approach can broaden the general understanding of science and produce scientifically literate citizens, we shall have taken a step forward.

Of course, it needs to work the other way as well. It is important that scientists learn how non-scientists view the world and that they come to understand the value of that view. Dutifully sitting through the obligatory history of civ course and learning the relevant facts and dates (no problem – just like the periodic table) isn't enough either. Scientists need to have the experience of brainstorming problems that have no immediate and definite solution and learn how to live with that frustration.

What we really need for the 21st century is renaissance people who also have a specialty. These people would be superbly trained in their field of major interest, but they would also feel comfortable with other areas of learning, where they would enjoy dabbling without fear. Who better to do this than our gifted students?

PARENT TO PARENT

by Elizabeth Kendall

I remembered again that when my children are upset, they are often reacting to my feelings and emotions. ...As I became more confident with my decision, he became more comfortable with the school. It's amazing how much I learn when I step back and listen to the real messages my children send me.

September brought the beginning of the school year and a new preschool for my three-year-old gifted son. I agonized over the question of whether to send him to a structured environment or to a more relaxed environment. As he is my third and youngest child, I am quite familiar with this agony. It is present throughout the process of every "life-altering" decision made on behalf of my children.

When my son entered day care at 2-1/2, he was accustomed to being with a warm, gentle live-in babysitter from Brazil. We needed a more affordable situation, so after looking at virtually every possible day care provider, I decided on a local preschool with teachers bilingual in Spanish. At the time, my son spoke Portuguese and Spanish as well as he spoke English. I thought the familiarity of the language and some aspects of the culture would ease the transition. These teachers were also very prone to cuddling with the children. I liked that. I felt comfortable leaving my son there, and he felt comfortable too.

Later, he entered the "three-year-old room." This particular room had a large population of physically aggressive children. The "boys will be boys" attitude of the teacher contributed to the proliferation of violent games and aggressive behavior among the children. My son was learning behavior that was inconsistent with our family's values. Summer arrived, so I hired a part-time babysitter and kept my son at home. This was stressful and inefficient because I have difficulty focusing on my other responsibilities when the children are under-foot.

When the time came to select a new preschool, I chose the more structured environment because, although they were very firm about "proper" behavior, they let children choose their play activities for themselves. When my six-year-old daughter was three, I had considered this school for her. At that time, I had observed children in crisply pressed clothing, politely standing in line, waiting for a turn to speak with the teacher. Not wanting to see my socially compliant daughter become a programmed "Stepford child," I opted for a place where she could hammer nails and make mud pies. She was happy there. Now I was placing my son in the very same "Stepford child institution" I had previously rejected. The reasons were sound: independent activity, no violent behavior condoned, and structure and its inherent security. We had moved into a home we were remodeling, so my son had many opportunities not only to hammer nails but to build things and grow vegetables and dig in the mud.

Intellectually, I had worked out the balance between my options and my requirements for my son. Emotionally, I was still struggling with the agony, the uncertainty, my lack of confidence in my decision. This school required you to kiss your child "goodbye" at the door and walk away. This was very difficult for my son. After discussing my concerns with the teacher, the administrator, the pediatrician, and seventy-five other important advisors, I decided to give him a little time to adjust.

Miraculously, after two weeks, he began to discuss school with enthusiasm. He wrote notes and drew pictures to give his new playmates. I could kiss him "goodbye" at the door and leave with confidence that he would have a satisfying experience. Every day I noted his progress as he adjusted rather smoothly to the new school. One morning, as I adored him through the window of the classroom, I was reminded of an important factor in parenting. He was busy talking to a friend. His teacher noticed me and let him know that his mommy wanted him to wave "goodbye" to her one more time. He responded quickly and eagerly like a good son, knowing that I needed a little more reassurance from him before I could "safely" go off on my own. Then it became clear. I remembered again that when my children are upset, they are often reacting to my feelings and emotions. In this case, a large part of his discomfort was due to his perceiving my ambivalence about the school. He was dependent on me to make the correct decision. As I became more confident with my decision, he became more comfortable with the school. It's amazing how much I learn when I step back and listen to the real messages my children send me.

Mathematical Thinking at its Best

by Marcy Cook

As teachers of the gifted, our global goal should be to **provoke thought**. Our students have the right to think, and they need a classroom climate which promotes, encourages, recognizes, supports, and rewards **thinking**. We must constantly strive to locate or create problems which involve much more than recall. We need to be certain that the problems have an educative component, which means that the student will learn from attempting the problem (and that the teacher will learn about the student's thinking from the attempt.)

We must provide problem-solving activities which transcend the narrow confines of basic definitions, skills, facts, and procedures. Although assessment may be more difficult, we should be providing problems that are open—problems that will have more than one right answer or more than one way to reach the answer. We should be careful not to reach closure too quickly.

Example: give students the direction that each letter of the alphabet has a numerical value:

A	B	C	D	E	F	G	H	I	J	K	L	M
1	2	3	4	5	6	7	8	9	10	11	12	13

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
14	15	16	17	18	19	20	21	22	23	24	25	26

To find the value of a word such as "cat," we must add the value of "c" plus "a" plus "t" (3 + 1 + 20 = 24), thus the word "cat" is worth 24. Students could be challenged with problems such as, "How many cities in the world have a name that is a multiple of 10?" A piece of paper could be placed on a bulletin board so students could be encouraged to add new solutions to the problem. There is no need to "stop" the experimenting at the end of that math period or even that week. Perhaps the chart could be left all year long, with students adding to the list as they uncover new discoveries. For primary students, a more appropriate question might be, "How many animal names can we find with a value larger than 50?"

Problems need to be provided that have more than one right way to obtain the answer. Students should be aware of a variety of problem-solving strategies and should evaluate which *process* they use to solve a problem, as well as analyzing what other strategies could have been used to solve that same problem. A sample list of strategies is in the box.

Problem-Solving Strategies

1. Use trial and error (estimate and check)
2. Draw a diagram or make a model
3. Eliminate
4. Look for a pattern
5. Simplify the problem
6. Work backwards
7. Organize the information (table or graph)
8. Write an equation

Gifted and talented students should also be encouraged to create their own "good" problems and show various strategies that could be used to solve their own problems. They can be creative in math in other ways as well. How about designing a math bumper sticker? They can combine math and writing with such assignments as:

1. If you could adopt a number, which one would you adopt and why?
2. What color is math? Why?
3. What sound is math? Why?
4. If math could be an animal, which one would it be? Why?
5. Imagine a world without numbers. What would it be like?

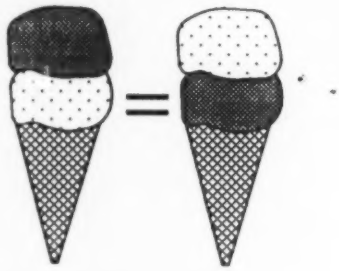
If we want to extend math for the able, we must provide opportunities to expand thinking and encourage creativity. We must expect divergent thought processing. Mere question/answer teaching, workbooks, rote learning, and textbook-based teaching do not improve skills in higher-order thinking. Higher-order skill development requires higher-order work. Students should often be directed to reach for

Ice-Cream Cones

An ice-cream parlor has eight flavors of ice cream:

CHOCOLATE	ORANGE
VANILLA	LIME
STRAWBERRY	LEMON
CHOCOLATE CHIP	GRAPE

How many different double-dip cones can be made?
(Vanilla-chocolate and chocolate-vanilla are counted as the same; top or bottom. Placement of flavor is not important.)



patterns or generalizations. Once a smaller problem has been presented and achieved, the students should be applying the learning to larger problems. A perfect example is the ice-cream parlor problem.

With "younger" learners we are satisfied with the solution to the problem, but extensions for the "older" learner are critical. "After solving the problem, could you find out the number of different combinations no matter how many flavors of ice-cream you had? How many different combinations could Baskin-Robbins make with 31 flavors?"

If we as teachers are providing the ultimate mathematical environment for our students, the learning of basic skills is being integrated constantly with thinking, problem solving, and reasoning. We should be breaking away from traditional questions with one specific right answer and finding ways to ask good questions; the art of questioning becomes the key to the thinking classroom. Rather than giving students a problem such as this: "Given a right triangle with one side 9 inches long and the other side 12 inches long, find the hypotenuse," a more valid thinking activity for a geometry class would be to ask students to write everything they can discover about a right triangle. With upper elementary students we often say "Find the area of a rectangle 4 feet by 6 feet." A more thought provoking problem might be to ask students to tell what they know about a rectangle with an area of 24 square feet. There is more opportunity to understand how the students think when we use the open question technique than when questions have specific right answers. As we open doors to thinking, we constantly must be careful to treat students' thinking with respect and view children's solution attempts as a part of the development of their mathematical thinking skills rather than as examples of faulty thinking that need to be corrected. (Paul Cobb, *Arithmetic Teacher*, September, 1988).

In a good learning situation students should be heard saying "I wonder if...?" "What if...?" "I wonder what would happen if. . .?" "Wouldn't it be possible...?" If these questions are not constantly occurring, we should re-evaluate the types of problems we are providing for our students. Our job, which is not an easy one, is to create an environment which challenges students to probe...to question...to persevere. We need to focus on challenging, questioning, and extending, while our students need to be visualizing, investigating, conjecturing, organizing, analyzing, validating, convincing, predicting, applying, generalizing, and evaluating.

The National Council of Teachers of Mathematics takes the position that mathematically talented and gifted students need an enriched and expanded curriculum that emphasizes higher-order thinking skills, nontraditional topics, and applications of skills and concepts in a variety of contexts. The major recommendation is to provide a broad and enriched view of mathematics in a context of higher expectation. We must look at restructuring the curriculum and instruction with an emphasis on higher-order thinking. There is no doubt that learning activities must be made more challenging and engaging. Asking students to **justify their thinking** may be one of the best ways to move toward creating a truly thinking program. The following problem is just one of many intriguing types of problems to encourage justification of thought.

There is no doubt that teaching the mathematically talented is a challenging task. The teacher of the gifted needs to have command of the subject matter, be committed to excellence, demand high standards, and be stimulating. The ability to provoke thought is a MUST!! As George Polya said, "What a teacher says in the classroom is not unimportant, but what the students think is a thousand times more important."

A number of years ago, one of the major California newspapers had an article which said "...there are very few teachers capable of inspiring students today. There are few challengers of the mind, few provokers of thought, few who can arouse one from the slumber of apathy..." As GATE teachers, we must be among those few!

Marcy Cook is a math specialist and consultant for elementary schools. She can be reached at P.O. Box 5840, Balboa Island, CA 92662-5840.

Explain Why Your Answer is Correct?

Defend Your Thinking!

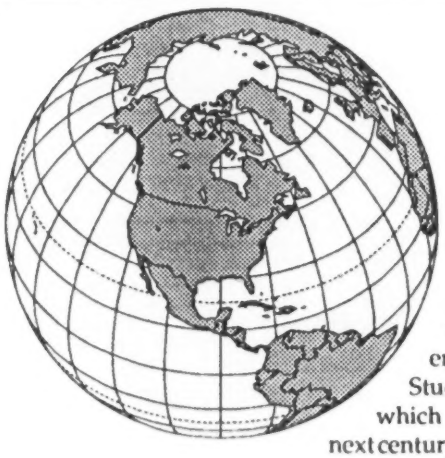
You have five wooden sticks which are unbendable and unbreakable, in lengths of:

1 inch	2 inches	4 inches
2 inches	1 inch	

Which of these figures can you make?

Explain why not for those which you cannot make.

- rectangle
- square
- scalene triangle
- quadrilateral which is not a rectangle
- equilateral triangle
- rhombus
- pentagon
- parallelogram which is not a rectangle
- hexagon
- isosceles triangle



California in the 21st Century

Summer School for High School Students
July 11-24, Westmont College, Montecito

You are invited to participate in an exciting new CAG-sponsored summer program for 100 students who will be in tenth or eleventh grade in the Fall of 1993. Students will explore the factors which will shape our lives into the next century. Topics to be considered are

- Political Implications of Cultural Diversity,
- Global Economy,
- Technological Upheaval, and
- Impact of Cultural Diversity on Society

Course work will be supplemented by numerous guest speakers and reinforced by student work on projects. It will be two weeks of intensity as students meet other bright and motivated students from throughout the state to explore the topics at hand. They will use the resources of Westmont College to prepare presentations and projects to share with the other students and to take back to their home communities.

The program will begin on Sunday afternoon, July 11, and will conclude on Saturday, July 24. The inclusive cost will be $800, for the program, lodging, and meals. Limited need-based scholarships will be available.

The campus is a beautiful wooded and secluded enclave near Santa Barbara. Transportation to Santa Barbara will be at the expense of the student. Arrangements will be made to meet students at the train or airport, if they are arriving by public transportation.

The staff will consist of Administrator Ann Cierley, four teaching faculty, and eight dorm and student life counselors. Students will be selected based on their transcripts, a letter of recommendation, and the student's statement of interest. Geographic, ethnic, and gender balance will be sought.

If you would like to participate as a faculty member or as a student, applications are now being received. Interested faculty members should contact Ann Cierley at 805/871-8950. Students should request registration materials from the CAG office at 818/888-8846. Further information will be available at the CAG Conference.

Math in Motion: A Hands-On Creative Approach to Teaching Mathematics in Elementary Schools Using Origami

by Barbara Pearl

I hear
and I forget.

I see
and I remember.

I do
and I understand.

Chinese proverb

Math in Motion is a "hands-on" creative approach to teaching mathematics in elementary schools using **ORIGAMI,** the Japanese art of paperfolding. "Ori" is the verb to fold and "gami" (kami) is the noun for paper. Paperfolding is traced back over 1,000 years ago to China and parts of Europe. The Chinese, who invented paper, used it to decorate their temples and shrines. Because paper was so expensive it was reserved only for the emperors and ruling class. However, as paper became more available origami travelled through Korea and then into Japan. Its roots stretch throughout the Asian continent. Famous European paperfolders include Leonardo Da Vinci and Charles Dodgson, better known by his pen-name of Lewis Carroll, the author of *Alice in Wonderland*. Dodgson was also a mathematican.

Math Anxiety

Do your students come to school excited about mathematics? Is math their favorite subject? Research studies indicate there is tremendous math anxiety prevalent in schools. The percentage is higher among girls, minorities, and low-income families. Many teachers and parents are uncomfortable teaching math and may contribute subconsciously to negative messages and lower expectations. They can help to counter these negative stereotypes and make significant changes in this area by encouraging positive math experiences where students can feel successful. A positive math experience is more important than ever in today's world, because a background in mathematics can open up a world of jobs, career opportunities, and choices for our students.

The illustration of math concepts using origami techniques demystifies math and reduces the fear of mathematics. It is particularly beneficial to gifted children because it stimulates and challenges their imagination and nurtures their creativity. Students get to *feel, touch, and see* the concepts being taught. They are directly involved in the learning process. This creative approach to mathematics develops meaning and understanding through manipulatives that create an exciting, enthusiastic math learning environment. Teachers discover special methods to ***focus attention and to sharpen concentration, memory, and recall.***

Enter the Fold

From an early age, children should be taught to examine the shapes of the world around them. Origami is related to geometry and invites children to explore abstract concepts. These concepts become *real.* Shapes and forms become part of their mental image of the world in which they live. Origami helps to bridge that gap between words and their meaning. Through the paperfolding process children feel successful and motivated to learn.

Children of all ages are captivated as they discover how to recycle magazines into geometric figures of birds or transform the morning newspaper into a three-dimensional hat. Polyhedrons, puppets, pinwheels — if you can imagine it you can fold it!

Origami is unique because you don't need to use other materials like glue, scissors, tape, rulers, protractors, or a compass — all you need is paper. The technique used is folding. The squares of paper are substitutes for a straight edge and a T square. Origami is like a geometric algorithm, in which you follow a sequence of steps to get the result. With origami, the results are meaningful, concrete, visual, and fun!

Through origami the students also get experiences in sequencing, organization, spatial relationships, listening and following directions, reading diagrams, critical thinking, problem solving, and developing vocabulary and concepts. The teacher can extend the folding lessons by focusing on methods of measuring length, angles, or area; testing congruence; and studying the attributes of plane and three-dimensional figures. Many of these skills can be transferred to other areas of learning. Students feel successful and develop a positive attitude toward mathematics and learning.

How to Get Started

Most libraries and bookstores have a wide selection of books on origami. Many libraries claim, "the origami section is wiped out!" This

popular art form is also a wonderful family activity and a great way to involve families in their children's mathematics education. If you are a beginner, look for books that have some written text. Some of the older books are confusing. It seems as though whole steps are missing (they assume you have a Japanese grandmother at home) and can be frustrating. Start with easier forms such as the drinking cup, boats, the house, whales, and flowers. The skill and confidence gained from previous successful experiences will enable you to visualize the spatial relationships and do more challenging folds. Practice makes progress and if you persevere,the results are worth the effort!

In the classroom you might begin with "the box", instructions follow this article.

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Sinicrope, Rose and Mick, Harold W., *"Multiplication of Fractions through Paperfolding," Arithmetic Teacher*, October 1992, pp. 116-121.

Skolnick, J., Langhort, C., Day, L., *How to Encourage Math in Girls*, Palo Alto, CA: Dale Seymour Publisher, 1982.

National Organization

The Friends of the Origami Center of America, 15 West 77th Street, New York, New York, 10024; 212/769-5635. Membership includes newsletters, annual convention, special events, lists of regional groups, and resources.

Barbara Pearl directs *Math in Motion*, which presents assemblies, student workshops, and staff development training programs. Directed toward the elementary student, these programs demonstrate how to incorporate origami across the curriculum and get students to think, talk, and write math. She says, "After a program, I observe children folding the models, experimenting with everything from notebook paper to scraps, challenging themselves to create different sizes, studying the intricate patterns they unfold, and exclaiming, 'I did it! I didn't know math could be so much fun! Teach us more!'"

Math in Motion uses paper folding as a tool that draws children into the world of learning. Origami takes a form so appealing that students are *eager* to learn. Ms. Pearl's vision is that *Math in Motion* will be a part of every student's experience. The program teaches patience, cooperation, precision, and an appreciation of other cultures. *Math in Motion* supports the California Mathematics Framework. It is designed to inspire student interest and mathematical understanding. The greatest value of the program is that students develop a positive attitude towards mathematics and feel successful.

Ms. Pearl says, "I believe that the negative association about mathematics is not *what* we are taught, but *how* we are taught. I hope you will open your minds and hearts and explore this creative teaching approach. You will discover some effective ways to revolutionize your teaching! An exciting, cultural, educational, and entertaining experience awaits you and your students. Perhaps there is a budding scientist, astronaut, or robotics engineer sitting in your classroom. Enter the fold with the lesson which follows and...*may the fold be with you...*"

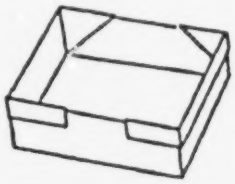
She invites you to write and share your experiences.

Featured on national television and in the L.A. Times, Barbara Pearl has presented at educator's conferences for CAG, Mathematics Council, and the California Association for Bilingual Education. She is currently writing a book. For a brochure and more information, send a SASE to: *Math in Motion*, 2417 Vista Hogar, Newport Beach, CA 92660; phone: 714/721-0633.

An Origami Math Lesson...The Box

Objectives:

- To develop auditory and visual attention skills (listening and following directions)
- To develop visual-motor skills (eye-hand coordination)
- To develop temporal-spatial concepts (the ability to understand the position of the self and objects with relation to each other)
- To develop shape and pattern recognition
- To develop sequencing skills (retain and recall information in appropriate order)
- To develop basic geometric principles
- To connect math and art



Strand: Fractions and Geometry

Concepts and Vocabulary:

fractions		*geometry*
whole	1	rectangle
halves	1/2	quadrilateral
quarters	1/4	triangle
eighths	1/8	line of symmetry
sixteenths	1/16	parallel lines, perpendicular lines

Materials:

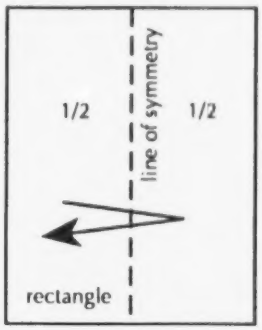
Sheets of 20-lb bond 8-1/2"x11" copy paper (use 2 sheets, one for the top of the box and one for the bottom of the box) This material is ideal because it is easier to write on and see the patterns and shapes in the paper. Notebook paper can also be used although it will be thinner. Hint: Make the top and bottom of the box exactly the same way. Adjust the top of the box over the bottom to fit.

Description:

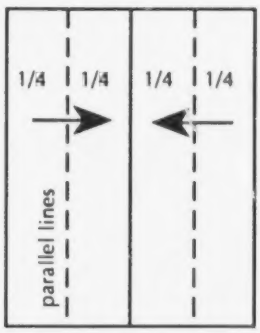
Use the box to teach a lesson on fractions or geometry. Refer to the concepts and vocabulary above. Model the process step by step using a larger sheet of paper. At each step, introduce or review geometric vocabulary and concepts. When introducing or reviewing vocabulary terms have students write the word and its definition on the part of the paper that represents that term. *Having the information go in your ears and out of your hands helps you learn it. When students get to feel, touch, and see the concepts being taught it reinforces learning and enhances memory and recall.* Select a few concepts to teach at one time depending on the abilities and experiences of the grade level you are teaching. However, don't underestimate the ability of the class. Children are more likely to retain information if they are actively involved in the learning process. Try introducing some of the new words like quadrilateral and symmetry to younger students. When children are interested in what they are doing they are curious and respond readily to new material.

***Note:** Each step is dependent on the previous ones. The creases and lines in the paper guide you to the next step. Emphasize the importance of precision and to crease sharply. The more precise students are, the easier it will be for them to follow the steps and the nicer the model will look.

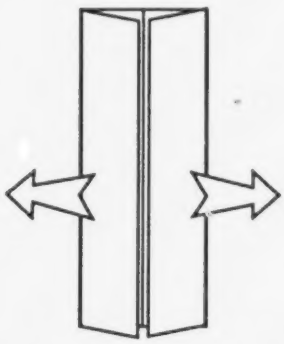
1. Fold in half lengthwise (Book fold). Unfold.



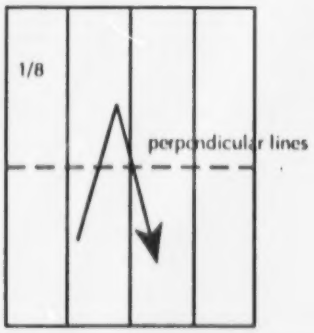
2. Bring longer edges to meet at the center crease (cupboard door fold).



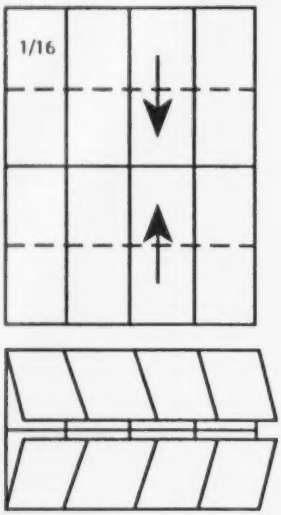
3. Unfold.



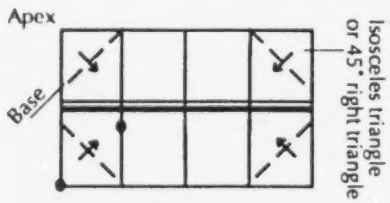
4. Book fold crosswise. Unfold.



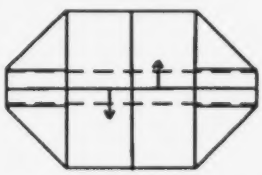
5. Bring the shorter edges to meet at the crosswise crease. This time leave the folds in.



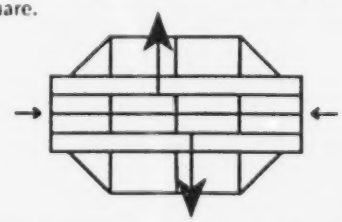
6. At each corner, bring the folded edge to lie along the nearest crease. Note that the cut edges do NOT reach the crosswise center line.



7. Fold the cut edges of the paper outward, one up and one down, as far as you can over the corner flaps to hold them in place.



8. Place a thumb under each of the "hems" just made and pull them up and apart. The ends of the model will fold upward to become the ends of a box. Pinch the corners of the box to make them square.



9. Voilà! A finished box! Make another for a lid.

How to Fold the Box...and related math concepts

There are so many applications for teaching a lesson using origami. The following is a sample of how to incorporate a math lesson using paperfolding. The adjacent figures illustrate each of the steps. During the lesson encourage divergent thinking by asking, "What can we say about the shape we see?" This open-ended question approach encourages students to analyze the figure without the pressure of obtaining *one* right answer. It enables the teacher to assess what the class already knows about geometry concepts and vocabulary.

1. Fold the rectangle in half lengthwise. Unfold.
   What is a rectangle? Another name for a rectangle is quadrilateral. Can you think of other quadrilaterals? When you unfold the paper, the first fold creates a line down the center, called the line of symmetry. The paper is divided into halves. Have students identify and label each part. Discuss or write a definition for the part.

2. Bring longer edges to meet at the center crease.
   Identify parallel lines.
   The paper is divided into fourths.

3. Unfold.

4. Book-fold crosswise. Unfold.
   Identify perpendicular lines.
   Each section is an eighth of the whole piece of paper.

5. Bring the shorter edges to meet at the crosswise crease. This time leave the folds in.
   The paper is now divided into sixteenths.
   How many rectangles can you find?

6. At each corner, bring the folded edge to lie along the nearest crease. Note that the cut edges do not reach the crosswise centerline.
   Each fold creates a triangle. This type of triangle is called an isosceles triangle. An isosceles triangle has two sides of equal length. The top of the triangle is called the apex. The bottom of the triangle is called the base. The sum of the angles is 180°. How many degrees are there in each of the angles of the triangles you folded?

7. Fold the cut edges of the paper outward, one up and one down, as far as you can over the corner flaps to hold them in place.

8. Gently fold back the sides of the model and pinch the corners along the seam of the box to shape your model.

9. As quickly as you can count to three in Japanese,
   - ichi,
   - ni,
   - san, you have created the box.

Make another one for a lid. Have students sign their models. See additional activities on the next page for follow-up suggestions.

Additional Activities with The Box

1. Measure length, width, and height of the box and then calculate the following:

A. What is the area of the base of the box?
A = lw (Area = length x width). Remind students that area is measured in square units.

B. What is the volume of the box?
V = lwh (Volume = length x width x height). Remind students that volume is measured in cubic units.

2. Challenge students to create three boxes of varying sizes. Experiment with different sizes of paper. Calculate the *area* and *volume* of the box based on the size of the paper used. Record findings in a table and summarize the results. Can students predict how to change the dimension of the box so that the area and volume are increased? Decreased?

3. Make nesting boxes that fit inside each other. Who can make the smallest box? Who can make the widest box?

4. This box was traditionally known as the magazine box. Recycle magazines and travel brochures. Use the front of the magazine for the top of the box and the back of the magazine for the bottom to create more decorative boxes. Display in the classroom or have a school exhibit.
5. Make a handle for the box and staple it to the sides to create a basket. To make the handle, fold the length of a sheet of paper in half, fold it again and shape into a handle.

6. Make a list of all the things you can store inside this box. These boxes could be used to store smaller items like paper clips, baseball cards, hair accessories, gifts, and more.

7. Decorate the box. Use markers, crayons, water color paints, and beads, or make a collage on the top of the box of your favorite things. Encourage creativity. Make two and donate one to a nursing home.

8. Write a poem and glue it inside the base of the box as a gift for someone special.

9. Give boxes as gifts for Mother's and Father's Days.

10. Teach someone else how to make the box.

11. Encourage students to work in cooperative groups and fold the model together. List objectives on the board and ask students to examine the folds and identify as many math concepts and vocabulary terms as they can. Have one student record the observations. After you fold several models together, you can ask students to list all their observations as a review or to reinforce the information. For younger children, the teacher can write down the student's responses on the chalkboard.

A Window Looking In

I am a window
Standing solemnly
Between two worlds looking in from the
outside.

I am blinded by light
Bright as the morning sun
As peaceful as the fall of a single
snowflake
More comforting than a mother's touch.

I see beauty in a way unknown to me.
All is in harmony.
Everything is fresh and new.
Innocence and purity lingers throughout.

I am on the outside.
Around me darkness forms
Darker than a starless night
More painful than a sharp blade.

The wind whistles with chaos and
disorder.
A bird is washed out of flight.
The trees battle the storm
Struggling for life.

Then silence soothes me.
The violent storm calms
Leaving me in quiet thought.
Life is renewed.

At times I wish I was looking out from the
inside.
But when the commotion stops
I realize that this is my home
And here I must always remain.

Kelly Dighero
Bella Vista High School
Fair Oaks

Accelerating in Mathematics: Academic and Social-Emotional Impact

by Terry A. Thomas

Educational acceleration, especially in mathematics, provides many benefits (Brody & Benbow, 1983; Daurio, 1979; Kulik & Kulik, 1984) and is generally endorsed as a useful strategy for gifted students (e.g., Cox, Daniel, & Boston, 1985; Feldhusen, 1989; Richardson & Benbow, 1990). However, the practice is viewed with suspicion by some educators. Resistance is often based on concerns about inadequate mastery of basics (Thurston, 1990) and preconceived notions about negative effects on social development and emotional well-being (Cornell et al., 1991; Daurio, 1979).

Talent Search programs based on the principles of the Johns Hopkins Study of Mathematically Precocious Youth (SMPY) are found in all 50 states and several foreign countries (Stanley, 1991). These programs have as their key elements the identification of academic talent in middle school youth through the Scholastic Aptitude Test (SAT) or similar tests; and development of talent through specially designed, accelerated classes, usually presented in a summer school setting.

The Academic Talent Search (ATS) at California State University, Sacramento is based on Stanley's model, teaching traditional high school mathematics (algebra through pre-calculus) at an accelerated pace to selected junior high-aged students in small groups with similar ability levels. Using methods which fly in the face of contemporary educational trends, these fast-paced mathematics classes have produced very impressive results. Students with identified talent in mathematics have mastered content that is traditionally reserved for older students, and they have benefitted from that achievement. Ongoing research investigating the impact of ATS acceleration confirms those benefits are substantial and long lasting. The purpose of this report is to describe the instructional approach of ATS fast-paced mathematics and to share current research evidence that ATS students gain academically and socially from the experience.

Ability Grouping

Classes are composed of 12 to 15 students who have similar ability levels in mathematics. Students are selected for placement into fast-paced classes based on several factors, including SAT scores, school mathematics grades, and diagnostic placement test scores. Age or grade level is not as important as readiness. Each instructional team is composed of a teacher and an assistant, a former ATS mathematics student. Team members are selected based on background knowledge in mathematics, and experience. Instructors may be local high school teachers or university faculty. The learning environment is rich in student-to-teacher ratio and in the high levels of achievement expected.

Pace of Instruction

Fast-Paced mathematics classes use a diagnostic-prescriptive model of instruction, which allows students to bypass the unnecessary repetition of content they already know. The Keedy-Bittinger textbooks, published by Addison Wesley, provide diagnostic pre-testing so that instruction can be tailored to individual needs. Students begin by taking an end-of-chapter test, and the items missed refer them back into that part of the chapter for study. Second, third, and even fourth equivalent tests are available to check student progress through the content of each chapter. When all the major concepts in a chapter are mastered to the teacher's satisfaction, the students are directed to the test at the end of the next chapter. In this manner, the pace of instruction is targeted to the needs of the students. Typically, students progress one or more chapters each class meeting. Homework expectations are high, with students studying mathematics two or more hours daily in addition to in-class work.

Teacher's Role

Independent study is not the only strategy. Class sessions are not mechanical, cold, and impersonal. While the teacher's primary role is to guide the students to understand the major concepts, class time is also used to expose students to problem solving and critical thinking activities which promote an appreciation of mathematics and provide opportunities for group interaction. Students are involved in short lectures, discussions, small group tasks, and one-on-one tutoring. Students get to know the instructors and their classmates, and many make new long-term friendships.

Competency Testing

When students complete the topics of a course, e.g., first-year algebra or trigonometry, they take a final test. Upon recommendation of the teacher, the student is administered one of the Cooperative Mathematics Tests (also published by Addison Wesley), with mastery defined as a score in the 90th percentile (using national norms). Mastery scores are achieved by the top ten percent of students who studied the same topics over a traditional 9-month school year. ATS recommends students with scores at the mastery level for credit, grade, and advanced course placement. Students are advised to take their ATS transcripts to their high school for such recognition. Students who show mastery in a course are encouraged to continue into chapters and topics of the next course. Those who score below the mastery level may re-test (on another form of the final test) only after they have reviewed their weak areas.

Over the past 11 years, 1300 mathematics students mastered an average of 1.32 courses in six weeks of study. Some students demonstrated achievement that would require two or more years of traditional mathematics instruction. Do students benefit from this high rate of achievement? Are there negative consequences? The students were surveyed at intervals of four and seven years to determine if they benefitted from ATS fast-paced math.

Four-Year Follow-up

A follow-up research study investigated the impact of this type of acceleration on students, four years after they participated in ATS summer school (Thomas, 1989). As part of this larger study, the 1984 fast-paced mathematics students were mailed a questionnaire in 1988. Completed questionnaires were returned by 56 of the 80 locatable fast-paced mathematics students, for a response rate of 70%. The high school students reported their experiences, academic achievements, and extra-curricular activities since Academic Talent Search participation.

Benefits

The outcomes from this study supported the practice of providing acceleration in mathematics for these students. Students viewed ATS as highly positive four years after participation in the program, and there was no evidence of systematic social-emotional disturbances or other harmful results. Student achievement in high school was outstanding, with average grades at the "A" and above category in all subjects. Students associated ATS with positive changes in their attitudes toward academic subjects, school, and self. They reported favorable changes in social relationships and emotional stability. The respondents were active in a wide variety of extracurricular activities, and they participated in free-time activities which are typical for the age group. The students had positive self-concepts, viewed themselves as being "in control" of their lives, and had formulated plans for the future, including career goals. They received awards and honors in a wide variety of fields, including sports.

The student comments below illustrate typical reactions to their ATS experiences.

The ATS experience has allowed me to take calculus, not only in my junior year, but at the age of 15! This has allowed me extra time to take classes in English and music.

ATS has helped me realize more of my potential academically and at the same time made me realize that I was not as smart as I thought I was. This helped me not to take my studies for granted ... that the competition in college will be a lot harder.

Seven-Year Follow-up

The same group of former fast-paced mathematics students was contacted seven years after participation in ATS summer school. These mathematics students were part of a larger study of the whole ATS class of 1984. Of the 80 former mathematics students contacted, 55% returned usable questionnaires. All of these students, ranging in age from 18 to 22 years, were attending college.

Outcomes

One indication of academic performance is the quality of universities students attend. These students had been admitted to an impressive array of distinguished universities. Almost half (48%) were attending a University of California campus, 12% were attending one of the California State University campuses, and 28% were at highly selective private colleges including Harvard, Harvey Mudd, Yale, Princeton, M.I.T. and Stanford.

Success in College

These students further demonstrated academic excellence by earning grades averaging "B+" (3.42 GPA) in their first two years of university study. Most students (64%) were pursuing majors in mathematics and related technical fields, including engineering, physics, chemistry, computer science, economics, and accounting. The others had majors that were less mathematics oriented, including business, biology, English, history, foreign languages, and political science. Predictions that accelerated students fail because of inadequate backgrounds were not upheld.

Goals and Aspirations

Students had established challenging goals for themselves. Academic goals were reported in terms of highest degrees expected. A high percentage (44%) of students intended to earn doctoral degrees, 36% were targeting master's degrees, and 17% expected to complete only bachelor's degrees. Career expectations were parallel to their choices of majors. Students reported career aspirations in medicine, engineering, law, and business. Twenty percent of these students indicated intentions of becoming teachers either at the high school or university level. One student was in ROTC and intended to become a naval officer.

Social-emotional

These students were not only high academic achievers, they were also socially and emotionally well adjusted. They were involved in many social activities both in and out of school. They had well defined inner locus of control and positive self concepts. As a group, these students were doing well in those areas beyond the academics.

Student comments included:

I am currently a sophomore at Yale University... ATS gave me confidence in my ability to challenge myself.

I remember feeling quite isolated at times in high school. Coming to Stanford was such a relief. I found a place where I could actually discuss books and issues with people. ... My peers motivated me to stretch my mind and I discovered I had a lot of untapped potential. The situation was similar to what I went through in ATS: working alongside of other talented students, I found I wasn't necessarily the "best," but I was inspired to achieve much higher levels than I expected for myself.

I had a much better attitude towards doing well in my classes after Talent Search. Now I am over half way through my college undergraduate studies working towards a bachelors degree in mechanical engineering...

Conclusions

Opponents maintain that accelerated mathematics students develop "gaps in their background" which show up later when they confront more advanced topics. Other opponents focus on the potential for social and emotional maladjustment. The ATS summer school provided acceleration in mathematics for small classes of academically talented middle school students grouped by ability. These students demonstrated exceptional levels of achievement in 1984, and have participated in two long-term follow-up studies. Results of the studies show these students have maintained a pattern of excellence in high school and well into college. Students report long-lasting benefits from participation in the ATS fast-paced mathematics program, and there was no evidence of negative consequences, academically or social-emotionally.

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Spotlight on Programs

"You've Picked Out All the Mavericks!"

Reminiscing about the Garden Grove USD GATE program with Jeanne Delp, Mary Ann Patterson, Sharon Clunk, and Mary Ann Price.

That's what the superintendent said to Jeanne Delp in 1961 when she assembled her first group of teachers for the district's fledgling gifted program. That qualification was fine with Jeanne. The whole idea of a gifted program was slightly maverick anyway, so teachers who were interested in doing something different and doing it in a different way were just what she wanted. "Intellectual zest" was her requirement for those teachers, and zest is what has characterized the Garden Grove program from the very beginning.

Jeanne's early experience with gifted education was in 1951. Just back from teaching American military children in Japan, she went to a summer program at San Francisco State on gifted education and went back to her school district eager to get some type of gifted program started at her school. It first took the form of the Friday afternoon "club," activities on Friday afternoons which would stretch and challenge the bright kids.

In 1961 when the legislature promised districts $40 per child to provide some form of differentiation for gifted students, Jeanne began to set up a program in Garden Grove. The program was to start with fourth grade, so she began by going into every third-grade class in the district, looking at cums, talking to the teachers, observing the kids, and then she made a list of children to be tested. With this pool of children cluster groups were set up within classes, since the superintendent didn't think the community would be comfortable with a pull-out program which would set some children apart. Jeanne began what has always been an important part of the Garden Grove program—meeting with parents. She explained why the children were chosen for these groups and what would happen to them there. She discussed the nature of intelligence and she talked about curriculum. She described the benefits to the child of being a part of this group, and she showed parents how to explain to a child what it meant to be gifted (and what it did not mean!) One of the first rules for parents was "no bragging," and she was very strict about this requirement. A gifted program should never be a cause for bad feelings in a school district. She also advised parents not to let the child make the decision whether to be in the program or not. Children, she thinks, do not have the necessary perspective to make that kind of decision for themselves. She then set up workshops to train third-grade teachers to work with these students in their classrooms.

It soon became evident that the need was for whole-day classes for gifted children, and the district felt ready. Jeanne got her "mavericks" together for a six-week summer workshop for intensive training and planning, and it was here that the Garden Grove gifted program was fully realized. The assumption was firmly held that the students must learn all the basic skills, but that they can learn them faster and more easily and then have time for enrichment. An early emphasis was on research and public speaking. Jeanne felt that if kids had all these great ideas, they needed the tools to develop them and communicate them to others. Fourth graders did "morning talks," fifth graders debated, and sixth graders did multimedia "morning projects." In order to have some "special" features of the program, and to enrich the social studies, units were chosen for each grade level. Fourth grade studied ancient Greece, fifth grade the Renaissance, and sixth grade did Shakespeare. The kids absolutely ate up these units, and students return from high school and beyond saying that they will never forget the Greek myths or having a part in a Shakespeare play. Research skills have always been emphasized and taught, with a lot of modeling of what makes a good paper and what makes a bad one. Content/style grades were separate, so the students knew exactly where they stood.

The teachers remember that first year as full of excitement. They met every week ("yeah, we met a *lot* ") to discuss what they were doing and how they could make it better. They invented their curriculum and they wrote units for each other to share and use. They picked ideas out of the air and brought the world into the classroom. Shortened versions of Greek

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tragedies and Shakespearean plays were performed, and dramatic productions have become a tradition in Garden Grove. They tackled art and music appreciation. They went beyond the basic reader and used paperbacks to teach reading. They wrote their own reading contracts for the books, and the students stretched their thinking powers with these contracts. They analyzed characters, wrote new chapters for books, did research about some part of the book, made maps, used new vocabulary in creative ways, and above all, they read *real* books for reading. Literature-based reading has always been a part of the Garden Grove gifted program, and it is a thing that the students and their parents remember with special pleasure. Those teachers remember the joy of having the freedom to be flexible and innovative in curriculum, but they all emphasized that a firm structure was at the base of the program. There was a sense of continuity from grade to grade and unity in the overall program. These are still strong features of gifted education in Garden Grove.

What is it that has made Garden Grove successful for so long? Jeanne Delp and the teachers who have seen their program educate a generation of bright kids are unanimous about what it takes to make a program last. First is a specific philosophy that all the teachers understand and support, a firm basis for the direction of the program. Next is a definite curriculum, one that has been carefully delineated and has specific objectives that everyone is working toward. Good communication with parents is vital and needs to be on-going. Parents must understand their children and the goals of their children's education. They must feel comfortable enough to ask questions and to seek problem solutions. The Garden Grove parent support group has become very active over the years and plays an important role in the program. GATE parents are good advocates for education. Finally, the coordinator for the GATE program should have GATE as her only responsibility, and built into the coordinator's role is active supervision of the program, to assure that long-term goals and objectives are being accomplished. Equally important, says Jeanne, the initiator of the program should never make it "my" program; it is "our" program, the district program.

Thinking ahead through the 90's, Jeanne says the basic question remains, "What is essential for the bright mind to know?" She underlines the same basic needs that were evident in 1961—competency in skills and the ability to communicate not only in speaking and writing, but in creative ways. The diversity of cultures evident in the society of the 90's brings a need for the development of skills in the arts of negotiation, persuasion, and discussion—skills our brightest students can learn and use effectively. Expertise in using the tools of technology is also a must for gifted students.

With a firm foundation and a proven record of accomplishment, Garden Grove is ready for the 90's and beyond.

Weavings in the Heart of the Young

The face
A tapestry of heritage,
Woven by the Master Artist.
Tough, leathery skin,
Stained by the sun,
Lines engraved by the sands of time,
Each with a story of long days of labor,
Twisting and winding over the surface,
Changing with each expression.
Eyes,
Pools of blue and gray,
Reflections of the sky,
Lost in the deep canyons of age,
Swimming in memories of youth,
Drifting across a sea of pain,
Reaching after a small piece of a star,
A dream lost in the pages of the past,
Big tired hands
Caressing skin that tastes and smells of youth,
Gazing into the heart of a child,
Relating the legacy,
Retelling the story,
With a passion of urgency,
Wishing and praying for one more day,
To run against the wind,
One more chance to truly live.

Anna Carlson
Bella Vista High School
San Juan USD, Sacramento

Spotlight

Profiles

"We Need to Teach Students to be Risk Takers."

A Conversation with Cynthia Rathwick

Cindy Rathwick, GATE Coordinator for Fresno Unified School District, considers herself a missionary for gifted education, because "I was one of those who was saved." She remembers the cloakroom, where she found herself "constantly in some difficulty or another." Two sixth-grade teachers decided that a challenge rather than more discipline was what this gifted girl needed, and the challenge worked. Though she describes her education as a serendipitous adventure, she became a serious student who couldn't get enough school, and school has become her life. Special education had been her field for many years, but when Fresno needed fresh leadership in its GATE program, Cindy was recruited. She had been effective in community-district conflict resolution during desegregation work in Fresno, and the district administration was persuaded that she'd be a good person to work with parents and teachers in a program that had its "ups and downs" in the district. The energy that fueled a rebellious student in Baltimore is now helping San Joaquin Valley children reach their potential.

The Most Important Issues Facing Gifted Education

We must be courageous enough to stand together and support the right of every child to an appropriate education. We have grouping for bilingual students to address their instructional needs. We have grouping for LEP students, and it's absolutely to be respected and fought for. We have grouping for special education, and we need those programs. Why on earth do we not support the right of every child with special needs to receive an appropriate education? I think that's probably the most critical issue facing us right now. If we can convince people to respect the right of every child to receive an appropriate education, I think American schools will flourish, and I believe that public schools of choice will be an enhancement in reaching this goal. Our school district allows transfers when parents cannot find the program their students need at their assigned school. Increasing numbers of principals are asking for GATE/Advanced Learner programs in their schools; and overall, gifted education services are in greater demand than ever before.

We must "cast a wide net" and open our arms, hearts, and minds to include many, many more students who come from diverse fields of experience. At the high school level more GATE, Honors and Advanced Placement classes are needed. Increasingly, teachers and principals realize that we can't address the needs of all special-needs children in the regular classroom. They are seeing that children who are very bright need to do more than be the teacher's helper or be assigned extra work; they need a challenging curriculum throughout their school day.

I believe that because of the range of student needs in our classes, the gifted child in the regular classroom may sometimes receive the least amount of directed teaching time. Teachers want to give their time to the kids who are barely making it and see that they have the survival skills needed to learn and grow. But how unfortunate it is that some of our other children may be feeling that they are out there on their own in their little rowboat going for it across the Atlantic. We need to make sure that **all children have support to reach their academic destinations.**

When I was special education coordinator, people would look at me and say, "Cindy, you're to be admired for your work." I had more sympathy than you can imagine. Within two weeks of my becoming the GATE coordinator, I felt as though I was the least sympathized-with person in the Fresno Unified School District. In gifted education, the trouble is that you can't always see a beautiful mind going to waste, and too often no one notices the very capable student who drops down and drifts, or in fact drops out of school altogether.

We must recognize the fact that the students themselves, especially in high school, don't always think it's wonderful to be smart; and we must strive to personalize our educational messages to students. About 10 or 12

years ago, three forensics teachers took a dramatic step in order to recruit high school students into more challenging GATE, Honors and Advanced Placement classes. They took a song title called, "It Ain't Cool to be Smart," and added in bold letters — "WHO Says So?" Inside, the brochure talked to the students about the advantages of a GATE education. It was an attention-getting device and a very effective recruiting tool.

I believe that when you have a strong gifted education program you uplift your entire school and your entire district. In this era of school-based management, how do you start a program at a school site? If we assist in a non-threatening way by listening and are absolutely non-defensive, the teachers who may start out being reluctant will eventually agree to begin a program at their school. I like to talk to faculties in small groups, and encourage them to ask me everything they've ever wanted to know about gifted education but were afraid to ask. Too often, the question arises, "What happens when you take away the cream of my class?" What really happens is that we allow all of the other "cream" (students) to rise to the top because we reassign those who may have developed a false sense of their own ability in a less rigorous environment. By placing gifted students together, they find out that, "Whoa, there are other very advanced kids out there. Now I need to work harder and smarter!" They learn an important real-world lesson in challenge and an entirely new layer of leadership develops in our mainstream classes.

Finding Gifted Kids and Measuring Results

The kids are here in bigger numbers than ever, and they're as bright as ever. In fact, they just may be brighter than ever because so many have had to work in a complex and sometimes threatening society to get where they are now in school. When I hear a teacher say, "I don't have the students to work with that I used to have. The kids are not as smart," I strongly disagree. We need to work to discover how we can better serve children who come to us from a world of varied experiences. We all need to do a better job of teaching to our new age students, but the talent is there. For instance, in Fresno Unified, our Advanced Placement success grew from approximately 60 AP exams passed in 1979 to approximately 700 passed in 1992; and Fresno Unified is a district where nearly 50% of the students receive AFDC (Aid to Families with Dependent Children).

We cast a very wide net in searching for children who would benefit from gifted education and changed the way we looked for gifted children. We stopped using individual IQ tests 12 years ago, and instead we informed and listened to the teachers. We asked the teachers to complete a student profile and to tell us who has the most sophisticated sense of humor, which student gives the most thoughtful arguments, which student comes up with creative solutions — and not to focus on the negative. So in Fresno we have a multidimensional approach to identification, which includes achievement scores, an assessment of reasoning capabilities, and a heavy dose of teacher observation, judgment, and recommendation. If you wouldn't want your doctor to diagnose your problem by using only a test and another objective test to pronounce you cured, why would anyone want to decide on appropriate educational placement and measure student success in such a simplistic manner?

We identify at least 7% of our population, and we include large numbers of others who are not identified in what we call the "Continuing Assessment" category. Some schools offer GATE as young as first grade. To be able to succeed in an AP class in high school and be able to write in the magnificent way necessary to score well on college exams, a student needs to be challenged from the very earliest age possible. In situations where students don't demonstrate high potential until their high school years, outreach, coaching, and tutorial programs can help them succeed in advanced classes. In our district high schools GATE, Honors, advanced topics, and AP classes are open to all ambitious students, and our AP success is above the county and state averages.

The Best of all Possible GATE Programs

If I could have anything I wanted, I think it would be a place where there were special programs for the special needs of every kind of gifted student. For instance, there would be schools of emphasis with performance-based character education and academic excellence being critical components of all of the curricula. **Instruction must be connected to the real world in which our students live,** which is definitely not the 50's! Some students might go to these specialty schools just part of the day, and their test scores would be credited to their home school, making magnets more welcomed

by the entire community.

Another dream would be to have K-12 schools as well as K-4, 5-8, 9-12 schools in a non-graded environment. University courses would be brought onto the campus, so students could work at the level for which they were ready—what one Des Moines GATE educator called "a seamless curriculum." We need to let go of grade levels. In Fresno Unified, once a student is in high school, she/he can take any class that does not have a specific prerequisite, regardless of age. That's very exciting. We need to have more faith in students' abilities to select what they can handle and what they cannot. Many of our students need subjects several years earlier than they are traditionally taught in high school. Appropriate, creative counseling can help. I would definitely have non-graded programs with more team teaching and teachers encouraged to specialize from first grade onward.

We need to have classrooms where students are encouraged to be risk-takers and where they know that it's okay to fail. When we started our elementary GATE program at grade four, we noticed that the students were cautious about raising their hands because they wanted to have the right answers all of the time. In GATE, they were with all these other bright students and they were reluctant to take the risk of being wrong. When we opened the program in grades one and two, we found that these younger students were bolder, unafraid of making a mistake, or not being perfect. We teach the children that it's perfectly fine to take risks. We work very hard at saying, "That's a very interesting answer. How did you arrive at that answer? Might there be other answers?"

Parent Empowerment is Vital

I have often been accused (justifiably) of being a very strong advocate for parents. I believe that parents are critical to the success of any GATE program. Parents know their children's needs and they can be our greatest advocates in our districts and the state capitol. Fresno Unified has a GATE parent empowerment conference annually, at which parent and school representatives work together to discuss the Big Ideas for the year. They also work in school pyramids (K-12), so that elementary, middle school, and high school can connect, align, and articulate. With school site councils becoming increasingly powerful groups, as they should be, the secret to the success of gifted education in a district may be determined by the way we present the needs of our children to the community .

After 35 years as an educator, Cindy Rathwick is still a missionary, and it's characteristic of her to say,

"If we are to be successful in our quest to equip our students with great character and a solid educational foundation, we must respect and listen to the joyous voices of hope and wisdom within all of us and realize that The Children Are Our Only Future."

ON THE LIGHT SIDE

by Jean Watts

"Since passion is the best predictor of future promise, we had no problem choosing this year's winner..."

TECHNET

by Terrie Gray

In this issue of the *Communicator* I begin a series of articles which share examples of how classroom computers can be used to meet the needs of gifted students. I will try to select lessons and strategies which can:

- be successfully used in both self-contained and heterogeneous classrooms, and
- provide opportunities for differentiating the curriculum.

These articles will feature software that facilitates the development of problem-solving skills and that gives students control over their own learning by making learning a process that is independent, individualized, interactive, interdisciplinary, and intuitive. The lesson plans detailed or reviewed will be those judged likely to cultivate an environment which promotes student control, and which concurrently promote the development of "gifted behaviors," exhibited in student products showing a high degree of organization, resourcefulness, complexity, in-depth understanding, and a logical presentation of research to support ideas.

Featured this month is *Space Station Alpha*, a classroom simulation based on the future colonization of another planet. This unit was developed by Greg Butler in association with Microsoft Australia, and is distributed by ISTE (The International Society for Technology in Education). The eight lessons contained on the disk use all the components of Microsoft Works, and provide an especially appealing approach to the introduction of the data base and spreadsheet applications.

Most computer-using teachers are comfortable with word processing, yet many shy away from teaching the data base and spreadsheet because they seem intimidating. The files on *Space Station Alpha (SSA)* come with prepared data bases and spreadsheets which allow students to gather, assess, and manipulate information. In each lesson are suggestions for enrichment and follow-up for the class, group, or student who wants to extend an area of study. Also included are resource pages containing information from NASA about space flight, and a data base of science fiction book titles. The lessons are appropriate for use with students grades 7 and up. Group work is encouraged, and there are several away-from-the-computer activities, so that the program can be utilized in a one-computer classroom

Anyone who wants a copy of the disk can send $6.00 to ISTE/1787 Agate Street/Eugene, OR 07403-1923. Or you can mail me a disk and I will make you a copy for the Mac. Please only send one disk per school. We are free to make copies, but may not sell the program. My address is Terrie Gray, 461 Tiger Tail Lane, Paradise, CA 95969.

Preparation Time: Moderate—to prepare Student Handouts and Student Data Disks

Skills Needed: Students need to have mastered basic computer skills.

Lesson Time: Varies according to depth desired. The author of SSA expects that teachers will use the program as a basis for designing an activity for 6 to 8 weeks.

Equipment: Any Macintosh or DOS computer which has Microsoft Works

Material: *Space Station Alpha* Disk, the Teacher's Instructions in a Printable file on the disk, and the Student Handbook which each teacher prints out from the disk and copies.

Curriculum: The kit is developed around the themes of Colonization, Survival, and Space Exploration. The activities could be developed in conjunction with social studies lessons or science lessons on space or the environment.

Grade levels: 7 and up

Objectives: Students will become Information Managers as they develop skills in using the computer tools that manage word processing, data base, spreadsheet, and communications applications, to help them collect and interpret information, make decisions and present findings.

SPACE STATION ALPHA

The Lessons

1. In the introduction, students are informed that they were chosen as delegates to a meeting of the Future World League in Geneva, Switzerland, in the year 2010. In that meeting, all member nations agreed that a team needed to be sent to colonize another planet to relieve the pressure on overcrowded and resource-depleted Earth. Fortunately, the students are selected as pioneers for this venture. Unfortunately, there is a malfunction with the Molecular Transporter, and no one knows where they are sent. Thus, the Mission: to identify the planet, determine which crops can grow there, and how many humans can be supported.

Food Selection (DB)

Food Name	Asparagus
Sowing Method [Seed or Sow Direct]	D
Area Required Per Plant\Animal[sq m]	0.300
Time Till Producing [Weeks]	20
Climate [1 Cool 2 Temperate 3 Warm]	2 or 3
Yield Per Plant\Animal [Food Units]	0.50
Notes	Hardy plant that will do well in most soils.

2. Each team is given a Planet Report containing information gathered by planet-surface measurements of temperature, diameter, distance from Earth, and number of moons. Students are to compare those findings using the Record Selection function in a prepared data base of planet information to determine which planet is the one on which they landed.

3. Using the information about the team's planet gathered in the previous lesson, students are to use the Food Selection data base file to find out which plants will grow. Then, they are to experiment with the Food Planning spreadsheet to create a garden of a specific size that produces the most nutritious and plentiful yield possible. Because the amount of food produced is dependent upon climate, students are to calculate how many colonists can be supported per dome. (The program gives feedback to the students so they know if they have a less-than-acceptable variety of food: the spreadsheet will tell them it may support only 0.25 people! The most successful student team I worked with could support 16 people, but they would have had to eat a lot of pumpkins...)

   The final activity in this lesson requires students to create a keyed map for their garden.

Food Selection (DB)

Food Name	Climate	Yield Pe	Sowin	Area Req	Time	Notes
Beans	1 or 2	2.50	D	0.100	11	Climbing beans
Beetroot	2	0.25	D	0.020	11	One of the easie
Broccoli	2 or 3	3.00	S or D	0.250	14	Highly nutritio
Brussel Sprouts	3	6.00	S or D	0.400	18	Easy to grow bu
Cabbage	2 or 3	4.00	S or D	0.250	12	Nutritious, hig
Capsicum	1, 2 or 3	1.00	S	1.000	24	High vitamin C
Cauliflower	3	4.00	S or D	0.300	20	Must have ferti
Corn	3	4.00	D	0.125	14	Stalks can be u
Lettuce	1, 2 or 3	2.00	S or D	0.050	10	Needs well drai
Onions	1 or 2	0.25	S or D	0.040	10	Useful plant. Ca
Parsnip	2	0.25	D	0.015	19	High yield from
Peas	2	2.50	D	0.050	15	Good winter cro

Food Planning (SS)

	A	B	C	D
8				
9	Food Name	Number	Area Used (sq m)	Yield (Food Units)
10	Asparagus	5	1.5	2.5
11	Beans	15	1.5	75
12	Beetroot	10	0.2	5
13	Broccoli	10	2.5	30
14	Brussel Sprouts	10	4	30
28	Turnips	0	0	0
29	Chickens(Pair)	2	120	300
30	Goats(Pair)	2	200	800
31	Cow	1	600	1200
32				
33	Totals		1009.95	3347.50
34			Area Used (sq m)	Food Portions
35				
36	Number of people garden would support:			1.02
37				

4. The information from lesson 3 is used as students decide how much of the planet is to be devoted to populated areas and how much to wilderness. The team members enter a proposed ratio into the Planet Population spreadsheet, which automatically calculates how many colonists would be able to inhabit the planet. In this activity students are directed to print out bar and pie charts.

5. Students prepare a Declaration of Colonization or a Warning Against Colonization using reports from the previous lessons.

6. Students write a constitution for their new planet, using the word processor for drafts, revisions, and final copy.

7. Each team designs a flag for the new planet (non-computer task).

8. Telecomputing Declarations: Teams use the Communications application and a modem to transmit the word processor file that contains the Declaration or Warning from task 5 to another classroom. Ideally, the recipients would also be working on the project so students could compare notes.

After the simulation is complete, students will be capable of adapting the prepared files for their own use—to demonstrate the effect of European colonization of the Americas, to write a constitution from the Native American's point of view, to chart the effectiveness of fictional colonization efforts, or to calculate the effect of a toxic spill on wildlife species. *Space Station Alpha* is just the launching pad, and the possibilities are endless.

Terrie Gray is the Parent Representative for the Mount Shasta Region on the CAG Board and can be reached at 916/877-5141.

Pride

He visits you when you get an "A" on a test
He visits you when your team beats the best
When you get a compliment you feel him inside
This emotion is not easy to hide.
When you help someone with their work
Inside you, this feeling does lurk.
So when you're feeling down, don't let this feeling subside
Remember always, this emotion called PRIDE.

Catharine Corpuz
Moorpark High School

Barbara Graham's Animal Classroom

by Barbara Graham

As a sixth-grade teacher for the Manhattan Beach City School District in Manhattan Beach, California, I teach math, science, and literature. I am committed to teaching with the concepts of whole language, themes, and integration of subjects, and with the strategies of active learning, cooperative learning, daily and extended investigations, and authentic assessment. I feel strongly that children should write in all subjects and that skills can and should be taught in the context of the theme and the assigned writing. Borrowing the phrase "learning to write, writing to learn," I teach to the premise that

students learn to write by carrying papers through all steps of the writing process from first draft to final copy. I feel that students write to learn and cement their learning by sharing their thoughts, feelings, and knowledge through a variety of writing strategies and by writing for many different audiences.

I teach in a heterogeneous classroom with a wide spread of abilities. Gifted and Talented Education (GATE) students share my room nine out of every ten days. One day every other week they attend a qualitatively different GATE program. ESL students and the less capable students succeed well in my program because of the active learning, the "hands-on" investigations, and the highly motivating and universal bonding with the animals, which are an integral part of the classroom. The more capable students and, in particular, the GATE students are challenged because the investigations and written assignments are all open-ended and give many opportunities for higher-level thinking and for connections, elaborations, and extensions. My evaluation of assignments is authentic assessment of portfolios showing the performance activities the students engage in over a period of time.

This past October I spoke to Sandy Kaplan's and Sara Content's student teaching classes at USC about how I accomplish my teaching goals with the help of the animals which share my classroom. Sandy asked me to share my program with the readers of the *Communicator*.

I love and respect animals and have observed over the years the closeness which children feel towards animals, and their curiosity about them. I became convinced that animals could have an important role in a classroom, and decided to involve them in the math investigations, science themes, and literary works I use in my classroom.

For the past seven years, I have taught directly with animals by maintaining an Animal Classroom. This enables me to teach with an integrated whole language animal theme - "Animals as teachers and learners." In math and science, students observe, weigh, measure and graph the growth of animals. They learn about the geographic locations, ecosystems and biomes of various animals, and they study the heredity and genetic traits of animals. Students, in the role of mathematicians and scientists, write to the animals about what they are learning in class. In literature, students are immersed in novels and poetry which include animal themes, and they express their thoughts and feelings about the values we encounter in the literature we read. They read a variety of factual material about animals and categorize the information gained from their reading. In fine arts students study drawings, paintings, and sculpture, and analyze the artists' depictions of animals. Above all, they care for and love the animals in our room.

In the classroom, we have had mice, rats, hamsters, guinea pigs, tadpoles, frogs, toads, anoles, iguanas, snakes, turtles, hermit crabs, tarantulas, goldfish, fresh and salt water tropical fish, and birds. The students learn about the classes of vertebrates and invertebrates within the animal kingdom and the place of each of the classroom animals within these classes. They study thoroughly the characteristics and behavior of the animals sharing the classroom.

Each student writes an elaborate report about a particular animal which could live in a classroom. Each becomes a specialist about the animal chosen and teaches the class about its characteristics, development, and needs. The report includes a study of the geographic and ecological needs of the animal and a discussion of reproduction and heredity.

We very carefully and selectively breed mice, rats, hamsters, or guinea pigs. The students learn about the nutritional needs of a pregnant animal and observe the mother both before and after the birth of her offspring. The students keep a folder on each new litter, and when the babies are born, each child writes out a birth certificate. Students diagram the babies' development daily and write about their behavior and growth. They weigh and measure the babies in grams and centimeters and chart their growth, and learn to analyze these measures statistically, interpreting information on a graph. The students compare the appearance and behavior of a newborn baby animal with that of a newborn baby human. As the babies develop fur and markings, we compare mother, father, and babies and hypothesize about the dominant and recessive genes handed down from the parents to their offspring. Students discuss other possible breedings which would give us interesting data about genetics.

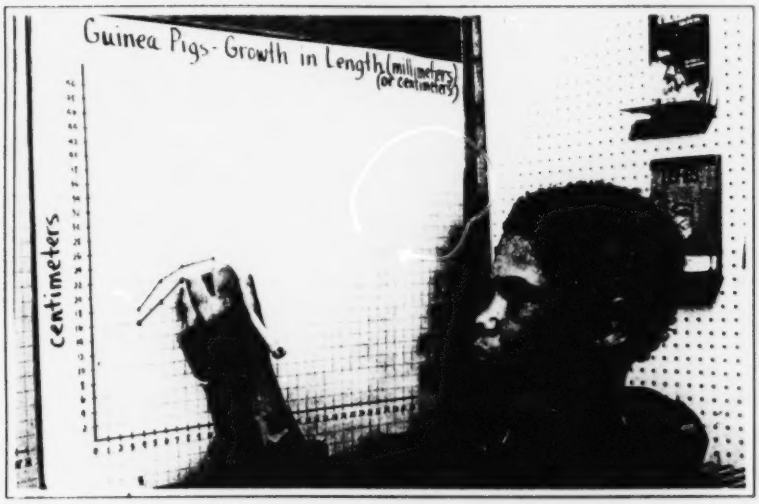
Students read novels which are about animals or that involve animals in their themes. One of my favorite books to study with a class is *The Secret Garden* by Frances Hodgson Burnett. A major theme of this classic is the development of character through relationships. A very contrary Mary grows through her relationship with the invalid Colin and the magical Dickon. Dickon has a special closeness with animals that allows him the privilege of knowing where the foxes hide their cubs, where the robins lay their eggs, and where the wild things have their holes. Through Dickon and the animals, Mary learns to feel emotions and share her new-found feelings with Colin and Dickon. The value of closeness in relationships transfers to the students in their relationships with the animals and with each other.

One particular passage from *The Secret Garden* has a beautiful description of the seeds, flowers, and animals in the garden. Focusing on the colorful language in this passage, I have the students visualize what they read and draw what they visualize along with a favorite line or two from the passage. One child drew seeds "planted as if fairies had tended them." Another drew "strange busy insect things running about on various unknown but evidently serious errands...a mole throwing up its mound at the end of its burrow...." The images become vivid as students write the author's words and interpret them artistically.

Another favorite novel in *The Incredible Journey*, by Sheila Burnford. A Siamese cat, a Labrador retriever, and a bull terrier embark upon a 200-mile adventure to be reunited with their family. Themes of this classic story include loyalty, dependence, persistence, courage, and survival. Students learn the "personalities" of the three breeds, their abilities and strategies for survival, and their weaknesses. They become absorbed in the story and search with the animals for their owners. We talk and write about survival and the need for loyalty, dependence, persistence, and courage in many of life's adventures. Students learn much more from animals than just information about animals.

We also read and learn to recite poetry about animals. The class loves "Mice" by Rose Fyleman. It states so clearly the attitude we have toward mice:

They nibble things they shouldn't touch,
And no one seems to like them much,
But I think mice are nice.



A more serious poem we study is "The Beasts" from Walt Whitman's *Leaves of Grass*. It appears as the introduction to *The Incredible Journey*. The poem contrasts Whitman's views of animals' needs and desires with those of man. Reading this poem leads easily to various analytical discussions of values, including one regarding the ability to feel contentment with one's surroundings and one regarding man's need for material possessions. After discussing the vocabulary and interpretation of this difficult but very significant poem, students respond to their favorite lines through words and pictures.

Observing the seeming contentment of a guinea pig lying peacefully in its cage, one student responded to Whitman's line, "I think I could turn and live with animals, they are so placid and self-contain'd, I stand and look at them long and long." She drew a sensitive picture of a guinea pig lying under a rainbow with a kitten lying contentedly atop the rainbow and wrote,

"I think the poem makes sense. Animals are very content. I think guinea pigs are the most content out of all beasts. It's too bad we can't be more like animals. Then there would be peace in the world once more."

Another student responded to Whitman's line, "Not one is dissatisfied, not one is demented with the mania of owning things." She drew various articles of clothing and a car, each with a line through it. She wrote,

"I completely agree with this. It's true animals don't have to worry about how they look or how they act. Sometimes I wish I was an animal. No worries. Just be yourself. They don't care what they have or what they want. When you're an animal, you're just a plain old general animal."

Students love to write to and about the animals. Students write and solve original math problems about animals, paralleling the concepts we are currently studying in class. When I make up a math test, I often include situational problems about our animals. Students write letters to the animals telling them what they are learning in various subjects. They write essays from the point of view of an animal living in our Animal Laboratory. They write poetry about the animals and do art projects about animals which are usually a part of their research report. They study learning theory and teach the animals to run mazes. They do observational experiments to learn the various food and sensory preferences of the animals. They study inventors and construct clever inventions for the animals. Skill development in language arts and other subjects is taught as necessary and relevant within the context of students' writing.

The students are responsible for the care and feeding of the animals. Periodically throughout the year and at the end of the school year, I give animals to very excited students to care for as pets. Students love and respect the animals in the Animal Classroom as I do, and many children stay after school to play with them. The animals fill a void in the lives of many children. With the help of the animals living in my room, the learning that takes place is very real.

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Fast-Paced High School Science for the Academically Talented: A Six-Year Perspective.

by Sharon J. Lynch

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Introduction

Interest in accelerated classes for gifted and talented youngsters seems to have been rekindled, especially in light of the ability grouping controversy (Hallinan, 1990; Robinson, 1990; Slavin, 1990a, 1990b; Welsh, 1990).

This paper discusses a program of educational acceleration in high school sciences at a special summer residential program for academically talented youth, initiated in 1982 by The Johns Hopkins University Center for the Advancement of Academically Talented Youth (CTY). These courses were designed to teach introductory high school biology, chemistry, or physics to highly motivated, academically talented students 12 to 16 years of age. The courses were taught during the summer over a 3-week period. Students lived on a college campus and took only one course. The total amount of formal instructional time allotted for the fast-paced science courses was 82.5 hours. This differed dramatically from the 135 to 165 hours or more per course provided in most high schools.

Background

The basic premises underlying the courses for talented youth at Johns Hopkins (Durden, 1987) are that these students:

1. Should have an opportunity to fulfill their intellectual aspirations, regardless of the age at which their abilities first appear.
2. Should be allowed to advance educationally according to their individual rates of learning and levels of performance.
3. Usually learn best through appropriate curricula organized to respect a natural sequence of learning.
4. Should not be inhibited by inflexible, artificially framed curricula and unimaginative management of students' time that restrict students' motivation and thirst for learning.
5. Will best advance and mature in knowledge through full and creative use of available resources, both in school and out.

There is strong evidence that these academically talented students, when they first participate in CTY programs as 12 to 13-year-olds, have already attained the level of cognitive development—formal operations—required for the high school sciences (Keating, 1975; Keating & Schaefer, 1975; Rogers, 1986). The minimum Scholastic Aptitude Test (SAT) scores for 12-year-olds seeking admission to CTY courses were equal to the mean scores of college-bound high school seniors—a score of 500 or more on the SAT-Math and a combined SAT-Math plus SAT-Verbal of 930 or more. Approximately 1 in 200 American 12-year-olds would qualify for CTY science classes, based upon these criteria.

Whether the individualized methods found so successful for accelerated mathematics could be applied to the sciences, however, was a different issue. High school mathematics tends to be based upon mastery of specific processes that, in turn, supply elements in the construction of a developing conceptual framework for mathematical ideation. Mathematically talented students can learn these processes almost effortlessly and consequently build concepts quickly. The sciences, however, tend to be more content-laden, introducing unfamiliar ideas and vocabulary. They may involve laboratory work that cannot be readily accelerated. The content of introductory science courses, especially biology and chemistry, may not be as hierarchical in nature as mathematics. Still, there was reason to believe that the same general principles might be successfully applied to science courses requiring similar conceptual skills.

The purpose of these accelerated classes was to do more, not less—to put the students on the road to further achievement in the subject, not merely dispose of it early. Following the fast-paced science courses, students were expected to take College Board Advanced Placement classes, college science courses, or pursue other advanced study in science.

Part I: Result of the Fast-Paced Science Courses, 1982-87

Biology

Method. The fast-paced science courses typically had the following format (see also Stanley & Stanley, 1986; Lynch, 1990b): each morning, students met with their biology instructor (a high school Advanced Placement Program teacher or a college teacher) for 3 hours of lecture and discussion, followed after lunch by a 2 1/2-hour laboratory session taught by a college senior or a graduate student. Each evening, students had a mandatory 2-hour study period to do homework, laboratory reports, and readings.

The total amount of laboratory time allotted over a 3-week period was 37.5 hours. This is almost double the minimum standard required by the New York State Department of Education for high school laboratory science courses. (The New York State requirement for lab sciences is 20 hours per 1-year course. New York State was chosen as an example because it has specific requirements and because its educational system is generally highly regarded.) Laboratory experiences not only inculcate crucial concepts but also serve as a powerful motivator for adolescents. Moreover, since CTY encourages students who are successful in the fast-paced science class to skip the same course in their regular high school and proceed to more advanced work in science, it was important that the students were provided with the science experiences required by school districts to grant credit.

The text initially used was a college-level general biology text. This was later changed to *Biology: The Study of Life*, by Schraer and Stoltze (1983)—a standard, well-written high school text. Although students were generally able to handle the conceptual level of the material in the college text, the sheer volume was unwieldy in a 3-week course, and the depth of the material exceeded that usually required for a first course in high school biology.

Pretest achievement scores demonstrated that some of the most basic material could be dispensed with, and all students were well-prepared in mathematics.

Pretesting. Diagnostic/prescriptive pretests were given in order to ascertain the mastery levels of individual students and the topics that had been learned previously, and to obtain baseline data for the group. Over a 6-year period, the students' mean pretest scores on the Biology Achievement Test have been rather stable, although individual student scores have ranged from chance level (200s) to the 90th percentiles (700s). (It should be noted that the College Board science achievement tests—biology, chemistry and physics—are ordinarily taken by certain high school juniors and seniors who are applying to selective colleges and who have completed one or more years of the respective high school science.) The average pretest score of 473 (which is equivalent to the 25th percentile for the national norm group of high school students) demonstrates that these students had acquired some knowledge of biology at a young age. The average age of the fast-paced biology students was 13.6 years.

Posttesting. Students were posttested with a College Board Multiple Assessment Program and Services (MAPS) Biology Achievement Test. The average posttest score was 627, which corresponds to the 74th percentile for the national norm group (MAPS Users Manual, 1987). The gains in achievement measured over a 3-week period are remarkably stable from year to year, teacher to teacher, and site to site—a mean gain of 154 points. (Individual student gains have ranged from -10 to +320 points.)

Chemistry

Methods. The rationale and structure of the fast-paced chemistry course were similar to those of the fast-paced biology course. Students learned material ordinarily covered in a rigorous, first-year high school chemistry class in 3 weeks, or 82.5 hours of instruction. A good, standard high school chemistry test, *Chemistry: Experiments and Principles*, by O'Conner, Davis, McNab, & McClellan (1982) was used. Since 1985, the subject-matter prerequisite for fast-paced chemistry has been Algebra I.

Pretesting. In 5 years of testing, 339 students wrote the CEEB Achievement Test in Chemistry with an average pretest score of 428. This is approximately equal to the 8th percentile for the high school junior and senior norm group. Fast-paced science students were not entering the chemistry class with as much background information as in the biology classes. This is not surprising since both elementary and middle school science and health classes tend to emphasize life sciences.

Posttesting. After 3 weeks of instruction, the average posttest score on a MAPS Chemistry Achievement Test for 352 subjects over a 6-year period was 634, which approximately equivalent to the 69th percentile of the national norm group of high school juniors and seniors

who had completed one or more years of chemistry.

In 1985 students also took a form of the American Chemical Society (ACS) examination as a final test of subject mastery. The mean raw score for the 45 students tested on the ACS exam was 65.9, which was equivalent to the 75th percentile for honors chemistry students who had completed a 1-year high school chemistry course. Their performance further demonstrates the competency of students taking the 3-week course.

Physics

Methods. The structure and pedagogical techniques for the fast-paced physics class were similar to those used for fast-paced biology and chemistry. One important difference, however, was that there were two different fast-paced physics courses (as of 1985): one for students who have had calculus and the other for students who have had algebra II (geometry is also highly recommended). Although the same high school textbook, *College Physics* (Miller, 1982), was used for both courses, the content of each course was modified according to the mathematical levels of the students.

Pretesting. The average pretest score on the achievement test for fast-paced physics over a 5-year period for 213 students was 536, which is equivalent to the 34th percentile for the high school juniors and seniors in the highly able norm group.

Posttesting. The overall average posttest score on the MAPS achievement test in physics (for all fast-paced physics students regardless of their mathematical background) was 644, which is equivalent to the 70th percentile for high school juniors and seniors. Overall, the physics posttest scores, when converted to percentile equivalents (70th), were similar to those for biology and chemistry (with percentiles of 74 and 69, respectively).

Part II: Factors Affecting Science Achievement

The fast-paced science courses provided a unique research opportunity, in that students were in residence for 3 weeks in a setting where the number of variables affecting content mastery are inevitably reduced and controlled. Compared to a typical high school, there was relative uniformity in curriculum, pacing, amount of study time allotted, and access to resources for additional help. These were excellent circumstances in which to explore the relationship between science achievement and ability or age for academically talented adolescents.

Although the data for all three science courses do not offer grounds for firm conclusions regarding the relationship between mathematical and verbal ability and science achievement, the contribution of mathematical ability seems somewhat greater than that of verbal ability. (Zak, Benbow, & Stanley, 1983 found the same thing for chemistry at the college level.) For biology, there is little support for the contention that verbal ability is as crucial to achievement gains as mathematical ability.

Science Achievement and Age. Fast-paced science students generally ranged in age from 12 to 16 years, although younger students were occasionally admitted on a case-by-case basis. Overall, the data on age and science achievement show rather dramatically that traditional age-grade requirements for science coursework were not warranted for this group of academically talented students.

Conclusions

The results of this study of fast-paced science classes suggest applications for educators. Bright, highly motivated students with strong backgrounds in science need not spend the usual 135 to 165 hours of formal instructional time on introductory sciences. Conversely, for gifted and talented students grouped by ability, the time allotted for a high school science may remain unchanged hours—but certainly the pace, amount of material covered, and the level of the material should be altered according to the abilities of the students. In light of the current criticism of ability grouping, it seems critical that classes for the academically talented be defensible in terms of both differentiated curricula and measurable achievement results (Slavin, 1990a, 1990b).

For coursework like biology, the degree of repetition prevalent in many American K-12 systems (which often includes an emphasis on life science in elementary school, middle school life science and health, and high school biology) seems particularly unnecessary for academically talented students. Ability measures such as the SAT and pretesting would help select candidates for acceleration or inclusion in honors sections.

The results of the present study do not show any relationship between science achievement and age for these academically talented students, with the exception of biology. These

students are quite capable of the reasoning required in high school sciences. With the current movement toward abolishing ability grouping or minimizing it (Slavin, 1990a, 1990b; Robinson, 1990), the acceleration option may be taken more often in order to rescue talented students from the boredom that may result from a curriculum that is too slow or too basic.

If the students in the fast-paced science courses were able to do this work in approximately one-half of the instructional time normally provided in the regular school, one may conclude that they would fare at least as well in the corresponding science course provided at their high school, where the competition is not usually as strong and the instructional time is doubled and extends over 9 months rather than 3 weeks.

On the average, these students mastered science material 2 years before it is made available to them in a typical American high school, an achievement that does not seem particularly extraordinary if one compares the CTY curricula with that of other countries. Coombes and Keeves (1973) and Stevenson, Lee, and Stigler (1986) report that in Japan science courses in junior high school cover topics reserved for high school in the United States. Since the Japanese system provides this level of instruction for most students, it would stand to reason that science education in America could begin to offer classes traditionally reserved for high school to younger students—perhaps, at first, the academically talented.

This study contributes to the emerging picture of science talent and its antecedents by exploring the relationship between mathematical and verbal ability and achievement in science. Educators may find this information useful in considering prerequisites for honors science classes since the evidence is clear that IQ patterns alone do not contain sufficient information for forming special academic groupings (Slavin, 1988).

The most important conclusion, perhaps, is that talented students can learn high school sciences successfully at a far earlier age than is typically allowed in our schools. Although the current concern for improving science education for all children seems well justified, some additional attention to improving opportunities for the gifted and talented to advance in science at a faster pace would also seem warranted.

Acknowledgments

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Trains

A train of thought...
Train tracks...
Track meet...
Red meat...
Red rose...
Blue sky...
Purple rain...
Prince...
Princess Diana...
England...
Battle of Agincourt...
France...
Italy...
Leaning Tower of Pisa...
Pizza...
Forest trying to sing...
"The hand that rocks the Table..."
Movies...
Beaches...
Yellow sun...
Big Bird is yellow...
Sesame Street...
Television...
Commercials...
Mr. Clean...
My locker is not clean...
School...
Summer is almost here...
Vacation...
Transportation...
Train...
A train of thought.

Karen Churchill
Bella Vista High School
San Juan USD, Sacramento

Diamond

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our higher cognitive processes. We do not get new nerve cells in the cerebral cortex after birth. So now it is up to the environmental impact to determine further development of these precious brain cells. In our studies we have learned that an enriched environment can improve the brain at any age–in youth, adolescence, middle age, old age, and very old age. How essential it is to prepare that young brain for a healthy, productive life-style. Just as enrichment is beneficial, impoverishment is detrimental.

Therefore, the Lawrence Hall of Science (LHS), high up in the Berkeley Hills, is an ideal institution to serve as a role model to enrich young brains of every age. The Lawrence Hall of Science is the public service unit of the University of California at Berkeley for science and math education for grades K-12. At the present time, it is the leading center for K-12 science and math curriculum research and development in the nation. We produce materials for over one quarter of the nation's elementary schools.

Most people know us as a "dinosaur museum," but few in our area are aware of the number of programs created by our clever staff of about 300 people. We have four academic departments–Astronomy/Physics, Chemistry, Biology, and Mathematics. Where to begin with all of our programs? First, let us see how many people benefit:

- Over 300,000 people come to the LHS each year;
- 10,000 schoolchildren enroll in classes;
- 12,000 teachers learn new methods and science and math programs to take back to their classrooms;
- 130,000 children benefit from our outreach programs throughout Northern California (our vans go as far north as Redding); and
- 94,000 schoolchildren visit LHS each year.

The Great Explorations in Math and Science (GEMS) program–consisting of 40 teachers' guides for hands-on science experiments and covering such topics as liquid explorations, crime lab chemistry, convection, a current event, discovering density, acid rain, and rocket experimentation—serves the nation and 20 foreign countries. McDonnell Douglas has spent $375,000 to begin GEMS centers to train teachers in Southern California. The first one is in Huntington Beach. We hope to establish such centers in many regions of the state. Hughes Aircraft has signed an agreement with us to use our GEMS guides and FOSS (Full Option Science System) for satellite teaching. We have done our first satellite teaching in collaboration with the Spokane Educational Technology Center in Spokane, Washington, where teachers directly and children indirectly in the states of Montana, Idaho, Washington, Oregon, and Alaska benefited from hands-on LHS science programs. Satellite teaching will be able to reach children everywhere in the future. Receiving disks one foot in diameter will cost less than $10.00.

IISME stands for Industry Initiatives for Science and Math Education. In this program teachers work in industries for five weeks during the summer to gain experiences to share in the classroom and to enrich their learning so as to prevent boredom and burnout. Numerous industries and government labs—about 61 in the first seven years of the program—participate in this program, which is a good investment to ensure qualified employees in the future.

EQUALS, a math program for teachers, counselors, administrators, and parents, targets girls and minorities in grades K-12. This program has been extremely successful throughout the nation. The talented math educators at the Hall more recently developed FAMILY MATH, which teaches parents how to help their children with math at home. In the first two years, 90,000 copies of the book were sold. By invitation from the Minister of Education, I took the book to Taiwan in December 1991, and two days after I returned, Taiwanese representatives were at the Hall arranging for a FAMILY MATH symposium to be held in their country in April 1992!

I was also invited to Venezuela in May 1992 to introduce more information about the Lawrence Hall of Science. Their Minister of Education wants to emphasize ecology, so he is interested in our "Global Warming" GEMS guide in addition to FAMILY MATH.

CEPUP (Chemical Education for Public Understanding Program), a teacher enhancement program, deals with education on such topics as toxic waste materials, risk comparison, ground water investigation, and chemicals in food additives. CEPUP reaches many states in the nation as well as overseas.

ACCESS (Alliance for Collaborative Change in Education in School Systems) prepares minority youth for entrance into the UC system. This program is very active in both San

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Francisco and Oakland and receives some support from the Berkeley campus.

Other LHS programs in Oakland serve a total of 36,217 people in 23 separate programs.

MARE (Marine Activities, Resources and Education), a program that teaches young people about the ocean and its inhabitants, is our most recent acquisition. With over 70 percent of our earth occupied by water, how important it is for our youth to learn about the oceans and how to understand their potential.

Exhibits on the brain have also been developed at the Hall. How many people ever think about their brains and how to help them strive to achieve their optimum level? Presently, we have a traveling brain exhibit going to five other museums in the country. New exhibits dealing with the auditory system have been developed. A generous donor realized that many children don't learn because they do not hear well. Our new auditory exhibit will allow children to test their hearing and take the results home to their parents.

Our bookstore, Discovery Corner, has a marvelous collection of books about science and math and their contributors. Children enjoy the objects in the store often as much as the exhibits. If you want new gifts for the family, consider a drive to the Hall!

You might be familiar with our 60-foot life-size whale on our plaza. In May 1992 we obtained a 60-foot DNA climbing structure which will serve as a basis to design DNA exhibits within the Hall. From those exhibits we will develop classroom activities, which will in turn be written up in GEMS guides for teachers. And the cycle begins again with the next timely subject. What do you think that subject should be?

The Lawrence Hall of Science, which is only 24 years old, together with approximately 300 other science centers, offers a very realistic step in improving the education of the youth of our nation in the decades ahead.

Thomas-Vallens

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need for workers with math and science backgrounds will grow by 36 percent, and yet only 5 percent of our nation's 2.7 million scientists are women. At the same time, the National Science Foundation claims that by the year 2010, our country will need 700,000 more scientists and engineers — requiring at least three times as many women scientists as we are currently producing (AAUW, 1992b).

Top level executives from TRW, Digital Equipment, Hitachi, and others joined leading educators, corporate leaders, and public officials to form the AAUW Roundtable. Providing better opportunities for girls was among the top recommendations from the Roundtable:

> *"In the global economy of the twenty-first century, America will no longer be able to compete with one hand tied behind its back. Clearly, the competitiveness of tomorrow's America will be determined by the ambitions, abilities and achievements of the girls sitting in today's classrooms" (AAUW, 1992 b).*

The changing demographics of the work force are shaped by the current economic climate. These 1987-90 statistics from the U.S. Department of Labor illustrate the need for girls and women to be prepared for the work force in order to insure their financial survival:

1. 53% of mothers with children under a year old are in the work force.
2. 58.5% of the women who work do so because of severe economic need.
3. Women are making 70 cents on the dollar compared to men. In other words, a woman works 10 hours to make the same amount of money a man earns in 7 hours.
4. The most lucrative occupations for women are lawyers, engineers, mathematical and computer scientists, physicians, and operations and systems analysts. Of these positions, four out of five are highly technical, and two are directly computer related. (U.S. Department of Labor and the Women's Action Alliance, 1991)

In 1973, Lucy Sells identified math as the "critical filter" as to whether women would be in the higher paying fields of math, science, and engineering (Sells, 1973). That fact remains true today. As reported in *The Wall Street Journal*, "Women who took more than two college-level mathematics courses often achieved pay equity with men and in many occupations received higher average pay than men did." Citing the work of researcher Clifford Adelmen in the *Journal*, "More math means more money." This is particularly true for women. (*The Wall Street Journal*, Sept. 11, 1992).

Women can no longer be considered to be "just homemakers and moms." In fact the average woman can expect to spend thirty-four years of her life in the labor force — many more years than needed to raise children. (Project VOICE, 1991). With such a tremendous need for women to be gainfully employed, they must

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have the chance to work in the fields that will best serve their economic needs and those of our nation. Math and science education for girls and women is now a necessity.

What follows are the major issues that continue to keep girls out of math and science: beliefs about genetic differences between males and females, biased educational practices, and societal stereotypes. New paradigms need to be created to make math and science more meaningful and accessible to the other half of our population.

Genetic Differences between Girls and Boys

New brain research as shared in *Scientific American* and *Time Magazine* point out that there are indeed differences in the chemical and hormonal make-up of male and female brains. Males, as a whole, have some advantages over females, especially in spatial ability. This skill, often needed in math and science fields, refers to the ability to mentally rotate or manipulate an object in space, and to construct three-dimensional objects. Females, as a group, have the edge on tasks involving perception, language, and mathematical calculation (Kimura, 1992 and Gorman, 1992).

While some may point to these differences as an explanation for the predominance of males in the areas of math and science, the differences are not great enough to account for the high discrepancy in the numbers of men and women in these fields. Additionally, the findings reported represent how males and females do on the average and do not account for individual strengths and weaknesses. Researcher Melissa Hines of UCLA reports:

> *Most of the gender differences that have been uncovered so far are, statistically speaking, quite small. Even the largest differences in cognitive function are not as large as the difference in male and female height. You still see a lot of overlap. (Gorman, 1992).*

Scientists have not been able to rule out the impact of the environment on gender differences. *Time*'s report states:

> *...research into innate sexual differences only underscores humanity's awesome adaptability... Even the concept of what an innate difference represents is changing. The physical and chemical differences between the brains of the two sexes may be malleable and subject to change by experience: certainly an event or act of learning can directly affect the brain's biochemistry and physiology... (Nash, 1992).*

The brain's ability to change due to experience raises the issue of whether or not we unwittingly deprive girls of the experiences needed to excel in math and science. Studies show that when girls are given the same training as boys, they improve their abilities.

> *...girls have equal or better spatial abilities than boys do in the early elementary grades. ... The spatial abilities of both boys and girls were improved by periods of classroom instruction in model building, working with three-dimensional objects, and solving spatial visualization puzzles. ...By senior high school, boys began to show, on the average, a slight performance advantage in spatial ability skills tasks. (Klein, 1989)*

Many researchers believe that the gender differences in spatial ability are further increased by the experiences boys have while doing certain "boy-type" activities. These include constructing model cars and airplanes, building with Legos, map reading in Boy Scouts, and active involvement in sports and other free-roaming play activities. (Klein, 1989)

Another area where ability comparisons are made between boys and girls are in test scores. High-school girls often get lower average scores on standardized math tests than boys. Again, some people may claim aptitude over experience; however, according to Department of Education researcher Adelman, "College-bound females who have had three years of math in high school get about the same SAT scores as males with equivalent schooling." (*The Wall Street Journal*, 1992)

Differences in girls' genetic ability in math and science cannot be used to justify women's relative absence in these fields. When given the same experiences and training as boys, girls do excel. In cases where girls don't succeed in math and science, they should be given the same kind of compensatory support we provide boys in the areas of reading and language.

Math and Science Gender Bias in the Classroom

Much media attention has been given to gender bias in education, thanks to the previously mentioned AAUW report. *How Schools Shortchange Girls* clearly delineates that girls are not receiving an equal education. The AAUW study and others suggest that girls acquire a "learned helplessness" from their school experiences. Boys dominate the classroom and receive more attention from their

teachers. Teachers are twice as likely to encourage boys to complete a task themselves. As a result, by adolescence girls lose their confidence and their self-esteem, and they gradually lose interest in their academic pursuits. (AAUW, 1992a)

Research shows that in the classroom, gender bias exists, especially in areas of math and science:

> *At both the elementary and secondary levels, when teaching math, teachers initiate more academic contact with boys — even when girls and boys initiate the same amount of teacher contact. ...teachers give boys more attention... and different feedback for wrong answers. (Campbell, 1986)*

As girls are ignored or treated differently by their teachers, their confidence in their abilities is shaken. Confidence is the most important variable in learning mathematics, according to research by Elizabeth Fennema:

> *Confidence is positively correlated with both math achievement and selection. Even when there are no sex differences in their math performance, girls tend to feel less adequate in math, to have a great tendency to underestimate their abilities, and to have less confidence in their abilities than do boys. (Campbell, 1986)*

Additionally, textbooks also perpetuate the notion that math and science are subjects for boys. Texts tend to show more male figures, present the findings of many more male scientists and mathematicians, and give science examples that relate to more "masculine" type activities and interests. When females are shown, they are often passive observers or recorders of data. (Klein, 1989) Whether it is deliberate or not, girls are repeatedly discouraged from pursuing mathematics and science by their teachers and by the materials they use.

Gender Bias in Society

The perception that math and science fields are for males predominates outside the classroom as well. Our culture has placed a much greater value on a young woman's appearance, conformity, and femininity than it has on supporting the development of her own potential. Our society views math and science as mainly the domains of males. The effect of this view is easily understood when our societal expectations are compared to other cultures. If parents don't perceive the fields of math and science as equally acceptable for girls and boys, parents are not likely to encourage their daughters to explore those areas.

> *In Saudia Arabia, for example, where society limits the number of acceptable career choices for women, only 5% of women pursue science-related careers. In Poland, societal views differ, and 60% of the women go into science. (Klein, 1989)*

Many parents feel that, because they were raised in the era of women's rights, gender bias would not be a trap into which they would fall. Many *do* believe that girls and women should and can be whatever they want to be. However, parents should consider the messages they are giving children about their own abilities as adults. A closer look at what happens at home may reveal subtle biases against daughters. When children come to parents with broken toys, how often are fathers the delegated "fixers and savers?" When math and science homework or projects require parental assistance, who helps out — mom or dad? What about the choices offered to girls for summer classes and extracurricular activities? How often do parents sign up girls for science workshops, math competitions, hands-on museum experiences, etc.? Parents are children's most influential role models and teachers. The example set at home is critical to the choices and experiences girls and young women will have in their lifetime.

New Paradigms for Bias-Free Math and Science Education

1. **GENETICS:** Girls are innately able to be successful in math and science. Raise the level of expectations for their success, and provide bias-free learning experiences that build their skills in spatial abilities.
   a. Give girls toys that will enhance their spatial abilities — ones that allow them to find relationships between objects, manipulate objects in space, take them apart and put them together again, and organize and group them. Building with blocks, setting up train track sets, repairing broken items, constructing puzzles and models, and experimenting with microscopes and magnifying glasses encourage these skills.
   b. Engage girls in what Sheila Tobias calls "street mathematics." (Tobias, 1978) Activities with balls, bikes and other hand-eye coordination type toys involve ex-

perimentation with the principles of physics, and other math and science concepts. Maneuvering a bicycle through obstacles, braking quickly to avoid a barrier, intercepting a thrown ball, calculating batting averages, observing ball trajectories, and hitting a target all enhance a child's inner sense of the physical world. Making and flying paper airplanes and kites gives children experiences with aerodynamics. Let girls be actively involved in these activities, even if it means getting dirty.

c. Have girls interpret and construct grids, graphs, charts, maps, and digraphs to help them understand two-dimensional representations. Encourage the use of tangrams, cubes, geometric solid figures, mirrors to explore symmetry, and pattern blocks to build an understanding of three-dimensional objects.

d. Seek games (board and computer) that apply the skills mentioned in "b" and "c," but are presented in formats that seem inherently interesting to girls, e.g., strategy games based on saving the environment from pollution or saving endangered species.

2. **EDUCATIONAL PRACTICES:** Girls have a right to a non-biased education. Subtle and institutionalized biases will not change without direct intervention. To create the needed changes, current practices must be examined specifically for gender bias.

a. Alert school boards, administrators, teachers, and parents to the biases against girls in school, particularly in math and science. Point out the long-range social, emotional, and economic consequences of these biases. Make sure fair allocation of resources is provided for programs that promote non-sexist career education, self-esteem, girls' athletics, math and science curriculum, and special activities such as math competitions, science fairs, and Invent America.

b. Review textbooks and other instructional materials for sex-stereotyping. Purchase materials that reflect equal access to the math and science fields. Look for ways that math and science curriculum can use examples that will tap girls' interests.

c. Check math and science enrollment, especially at the junior and high school levels. Send the message that algebra, geometry and beginning science classes are baseline coursework, and create the expectation that advanced courses are necessary for both boys and girls. Create peer role models by having girls in advanced courses "recruit" others to take these classes. Have them present experiments to students in prerequisite courses, and talk to them about the fun and excitement that can be had in higher math and science.

d. Teach educators questioning and responding strategies that promote higher level thinking skills and eliminate bias. Effective use of wait time, providing specific feedback related to the task, and promoting and acknowledging students' active participation in class will help *all* students succeed.

e. Use hands-on materials and expect girls to "do" as much as boys so they don't learn helpless-type behavior. In cooperative learning groups, rotate jobs so girls and boys have equal access to materials, leadership positions, and teachers' attention. Vary groupings to include coed and same-sex groups, similar ability and mixed ability groups, and those based on interests.

f. Be frank with students about gender bias. Point out how boys tend to capture teachers' attention, and provide students productive means to make changes themselves. Illustrate this by having students tally on an index card how often they are called on, and whether they were called on because of their attention-getting behavior, or for ideas they have to share. Follow this up by discussing students' perceptions and feelings about the kind of attention they get from teachers. Then try to alter traditional means for calling on students, by drawing names from a hat, or assigning table numbers to students and rolling dice, for example.

g. Build the self-esteem and confidence of girls. To do well in math and science, girls need to feel confident about their abilities and how others perceive what they can do. They need to be encouraged to explore and take risks, and gain competency from learning by doing. Girls need to make decisions, learn from their mistakes, and think and speak for themselves. To do so, they must have support for doing so — not protection. They must be acknowledged for what they do well, and not just for how they look and behave. Strong female role models and mentors can help girls envision their own future as active, productive citizens.

3. **SOCIETY'S ROLE:** Girls and women will increase their contributions to the fields of math and science as doors are opened wider for them.

a. Businesses need to support the process of helping young women pursue scientific and technical fields. This can be done by setting up intern programs, mentor support, career awareness days and on-site visitations. Financial support for educational programs is needed. Lasting changes can't be made unless business and

industry embrace educational efforts to promote math and science success for girls.

b. Parents must check their expectations for their daughters, giving their girls the same freedom and flexibility to reach their potential as boys. They must remove the subtle limitations they are creating by the toys they select for girls, the activities they encourage, and the experiences they create. They can develop their daughters' interest in math and science by taking their girls to science museums, planetariums, and extracurricular math/science classes, and providing books and materials at home that utilize math and science skills.

c. Parents should take an active role in providing career exposure and counseling. They can assist girls in taking advanced coursework in math and science. They can seek out mentors and role models for them in industry. Outings to transportation centers, science labs, hospitals, wildlife centers, and high tech industries can be added to family activities.

d. Families should involve girls in everyday activities which utilize technical skills such as car maintenance, home repair, landscaping, and family finances.

Conclusion

The high school graduating class of the year 2000 is in fifth grade today. What happens to girls now in school will greatly determine whether they will be prepared to enter college-level math and science courses needed in the workplace. Unless we actively make math and science more accessible to girls and women, we are limiting our technological competitiveness in a global economy. In a sense, we're competing in a game, but encouraging only half the team to play.

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